TRANSACTIONS

of the Wisconsin Academy of Sciences, Arts and Letters

Volume 84 • 1996

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

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

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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

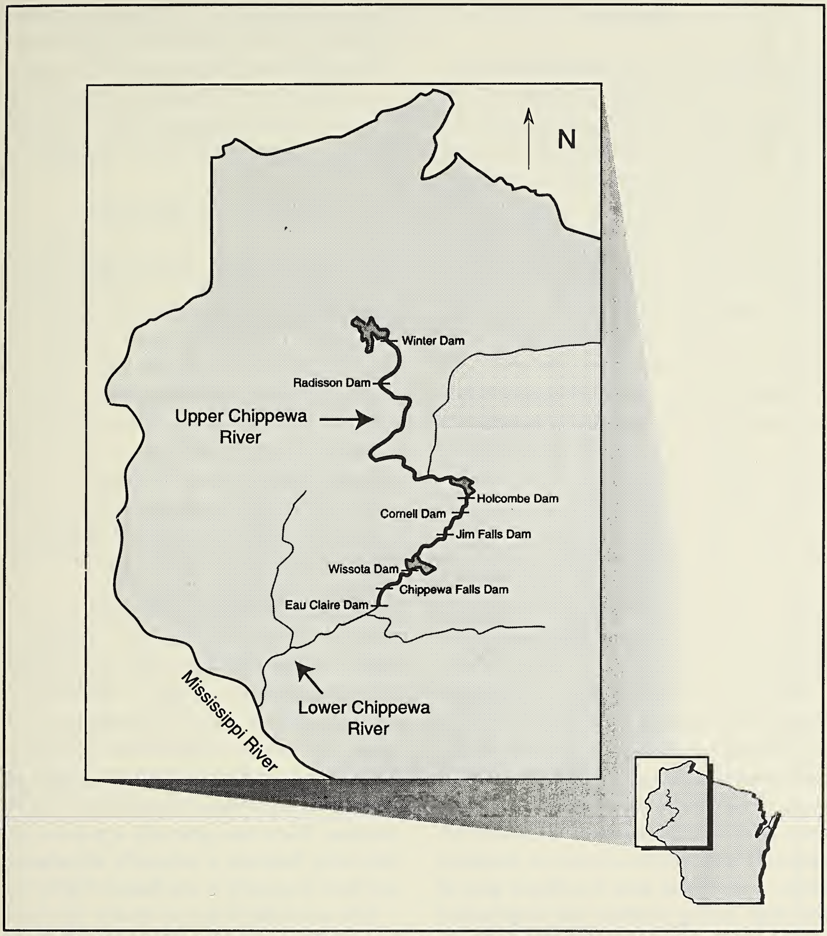

Figure 1. Reaches of the upper Chippewa River study area, from the Eau Claire Dam to the Winter Dam.

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.

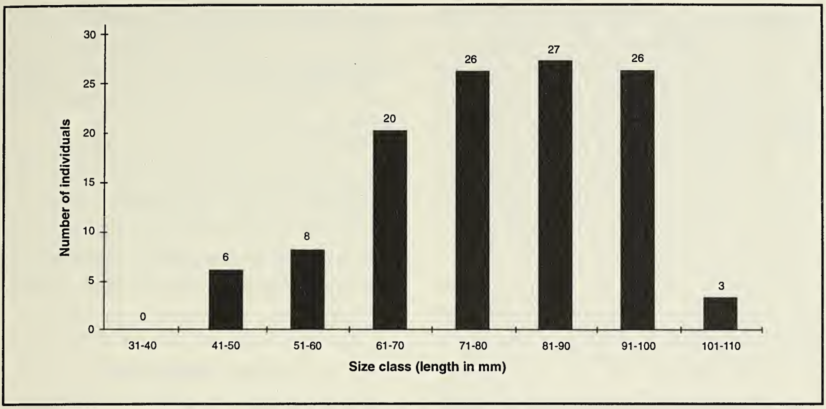

Figure 2. Size class frequency of *Cyclonaias tuberculata* in the upper Chippewa River, Wisconsin.

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

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-

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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%

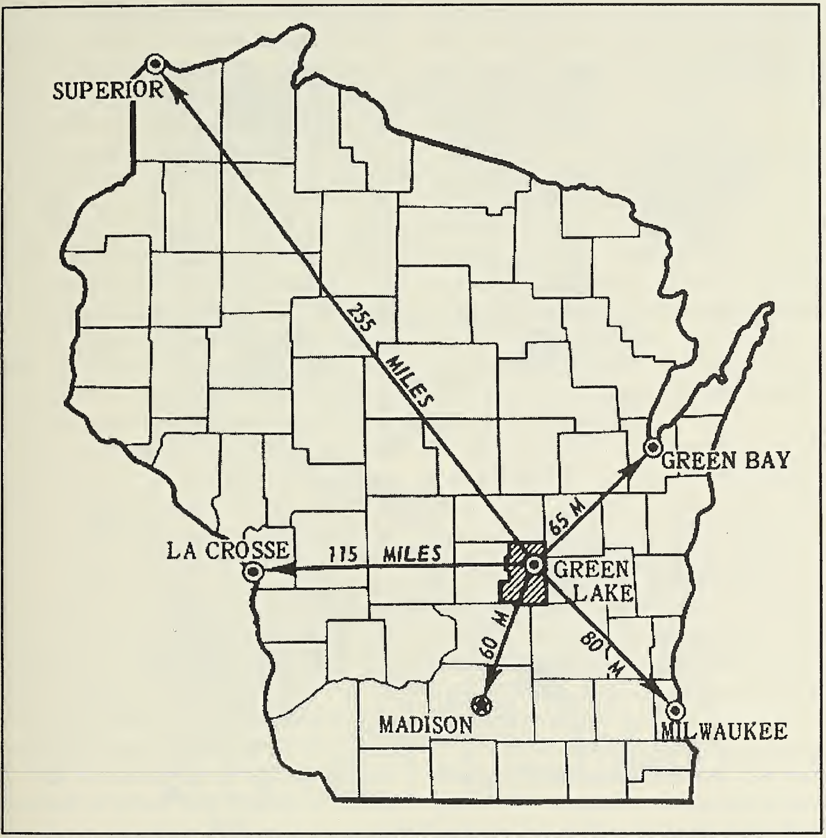

Figure 1. Location of Green Lake County, Wisconsin (U.S. Dept. Agr. 1977).

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

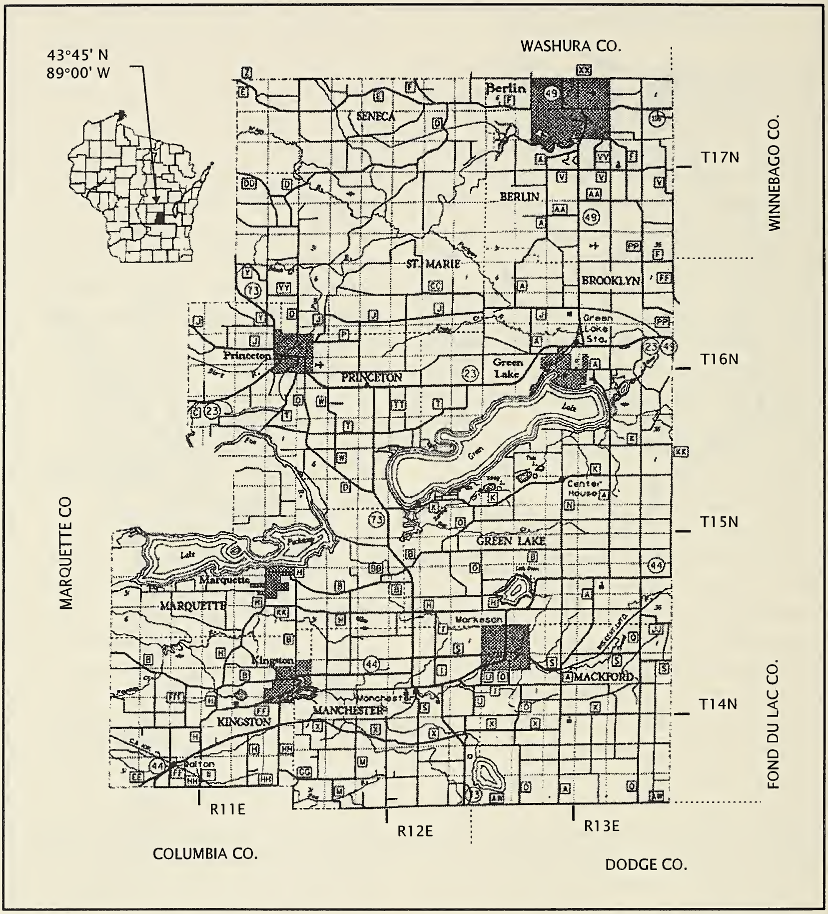

Figure 2. Green Lake County, Wisconsin, highway map (adapted from the Wisconsin Department of Transportation, 1988).

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.

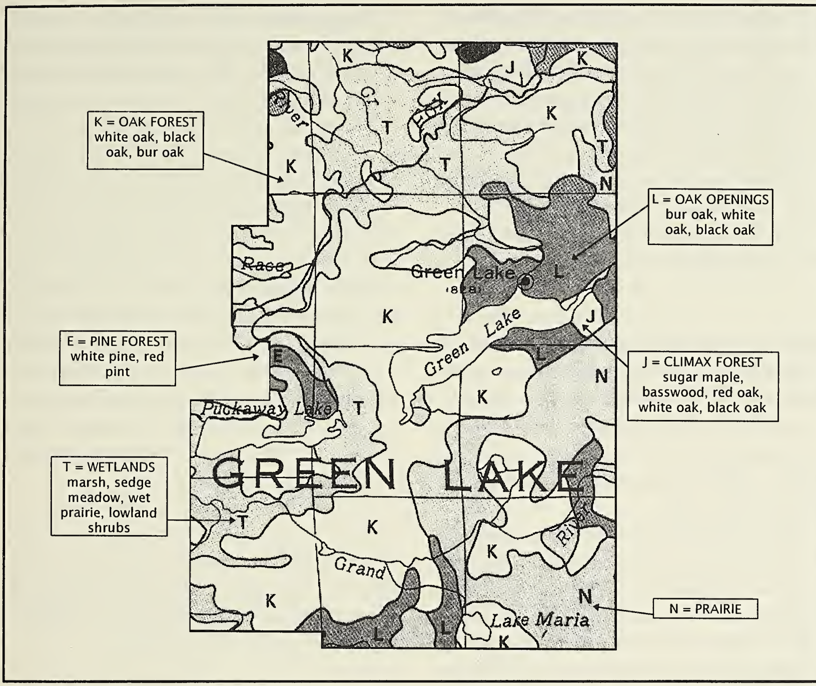

Figure 3. Presettlement vegetation of Green Lake County, Wisconsin, circa 1834 (adapted from Finley, 1976).

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; Jen nings 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.

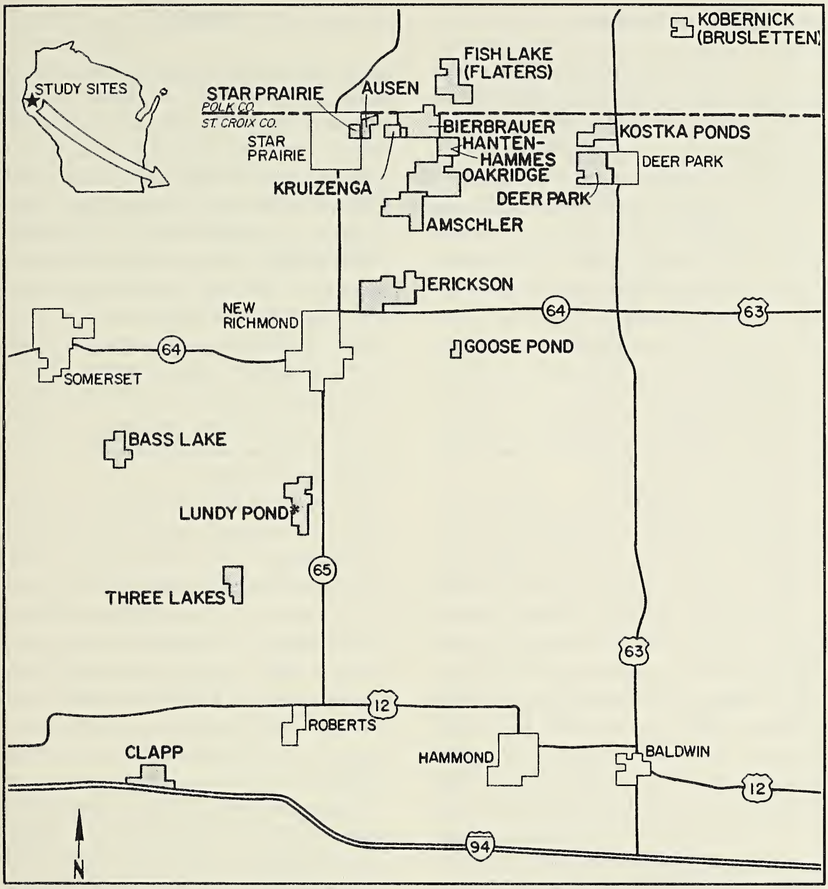

Figure 1. Location of waterfowl production areas within study area.

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 pre-flood 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 pre-flood 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 pre-flood 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-

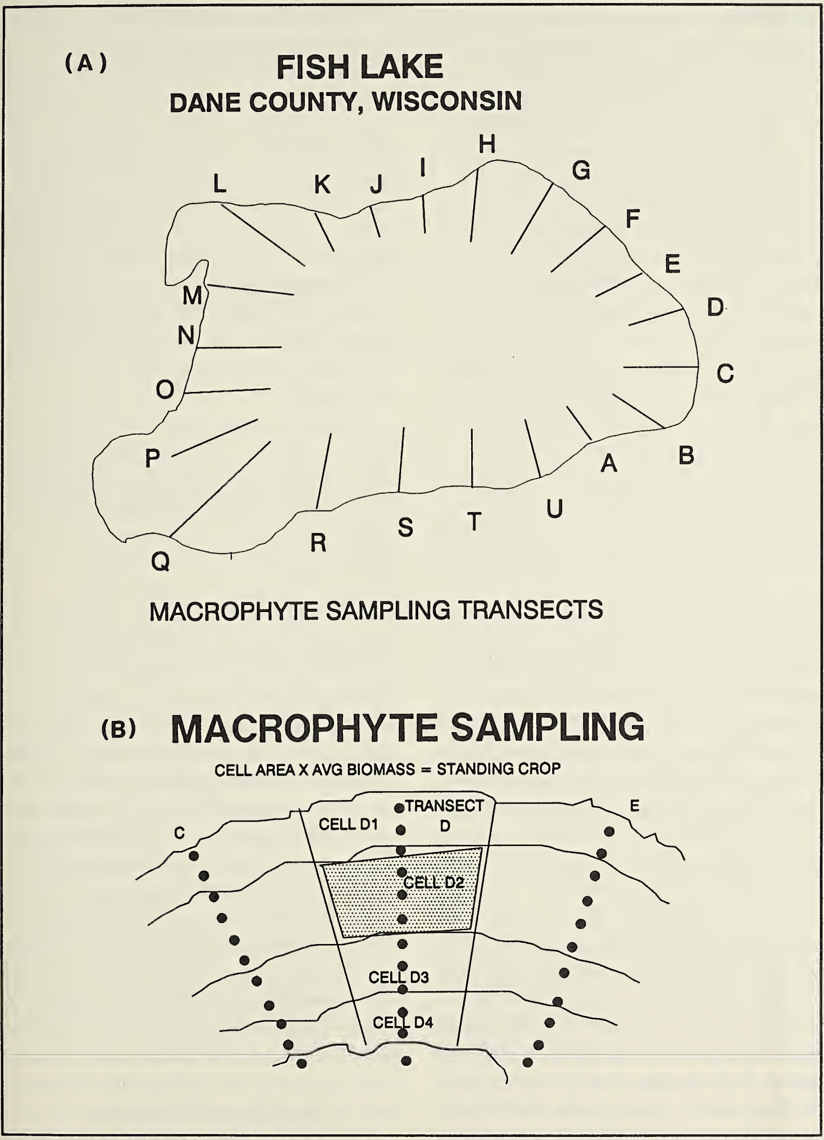

Figure 1. (a) Distribution of macrophyte survey transects in Fish Lake, and (b) areal cells defined by depth contours and boundaries between adjacent transects.

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-

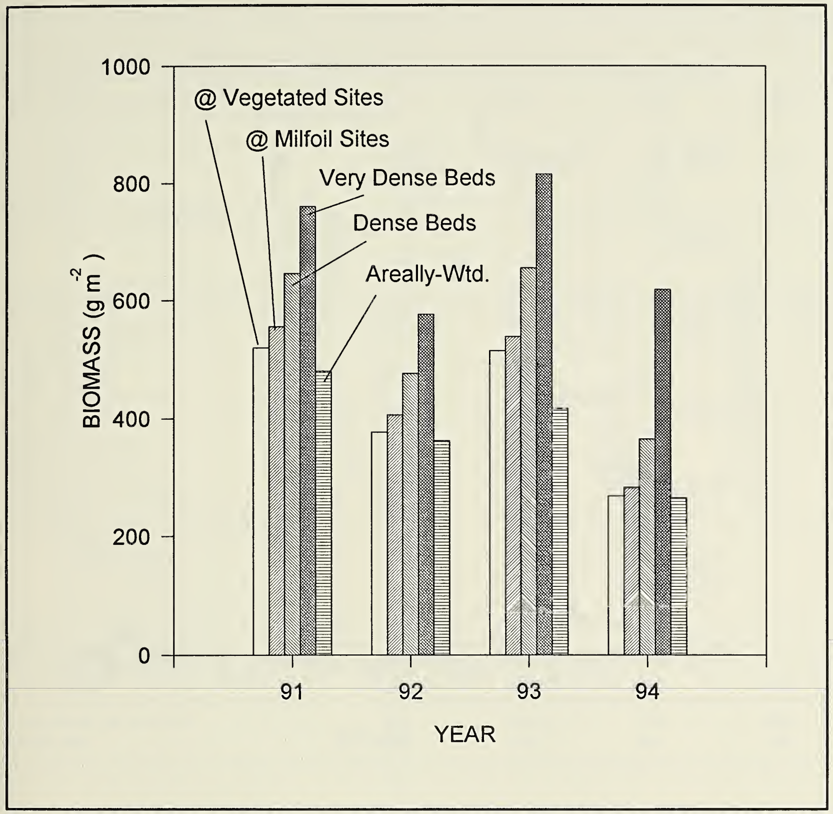

Figure 2. Mean dry weight biomass of milfoil across all vegetated sites, all sites with milfoil present, sites with dense milfoil (> 60 g m^{-2}), sites with very dense milfoil (> 300 g m^{-2}), and areally weighted estimates for the entire littoral zone (0–6 m) by year.

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.

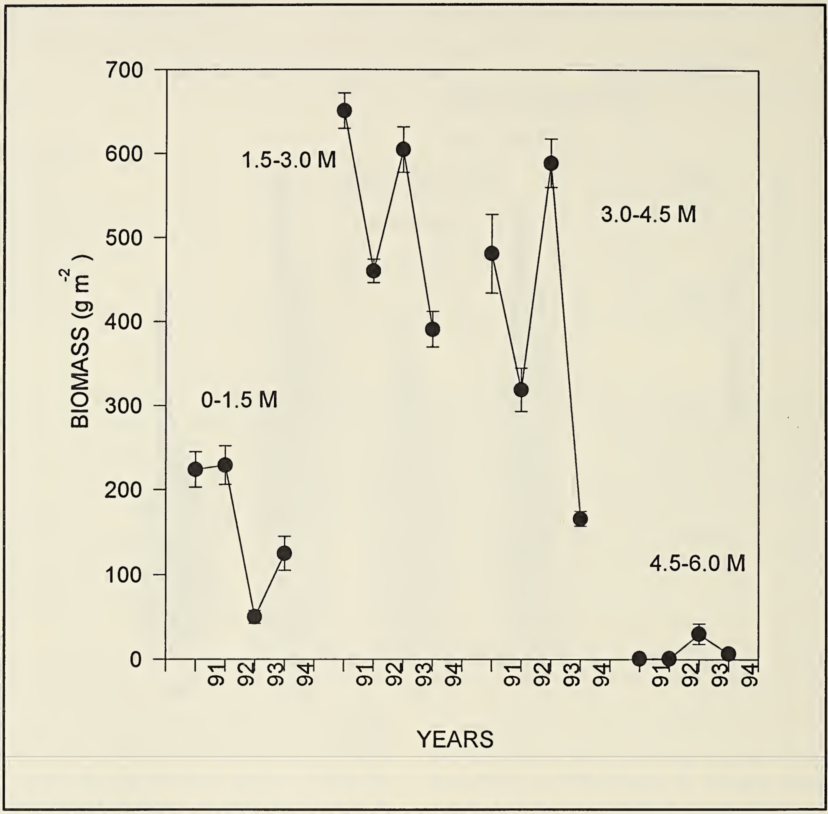

Figure 3. Milfoil biomass (mean ± 1 SE) by depth zone and year.

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.

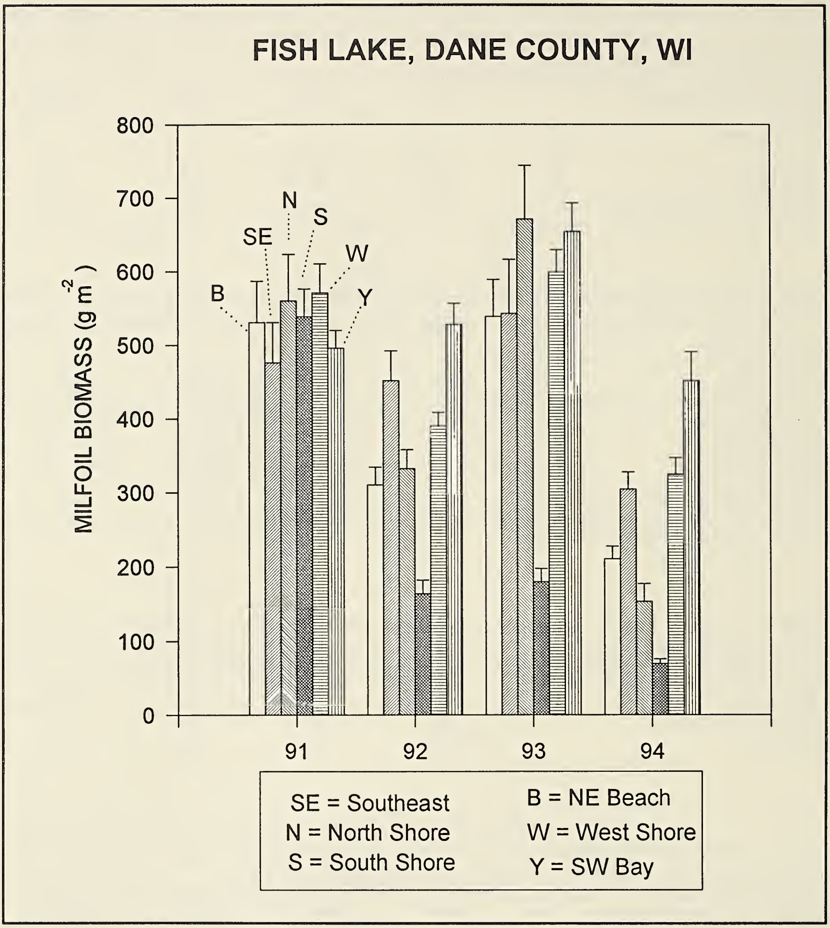

Figure 4. Distribution of milfoil biomass (mean ± 1 SE) by shoreline region and year.

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

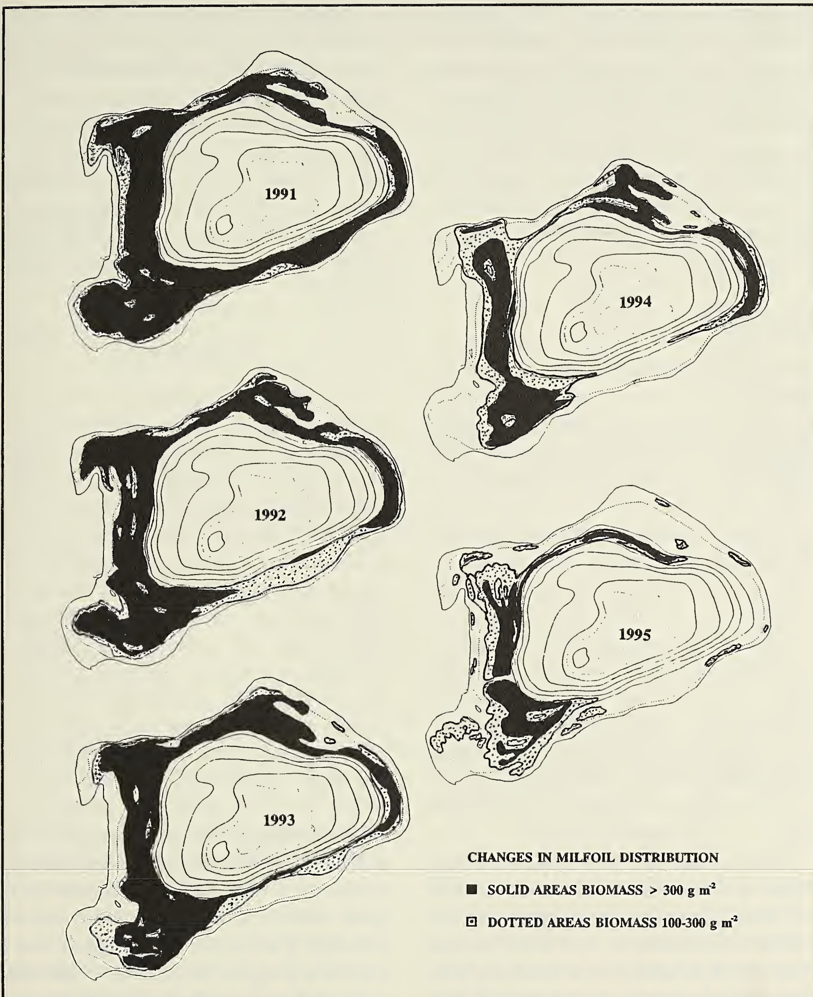

Figure 5. Changes in the distribution of milfoil beds in Fish Lake from 1991 to 1995 based on a combination of aerial photography and biomass transect data. Depth contour lines are shown as solid lines for 10 ft intervals (dashed lines represent 5 ft and 55 ft intervals).

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).

Acknowledgments

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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

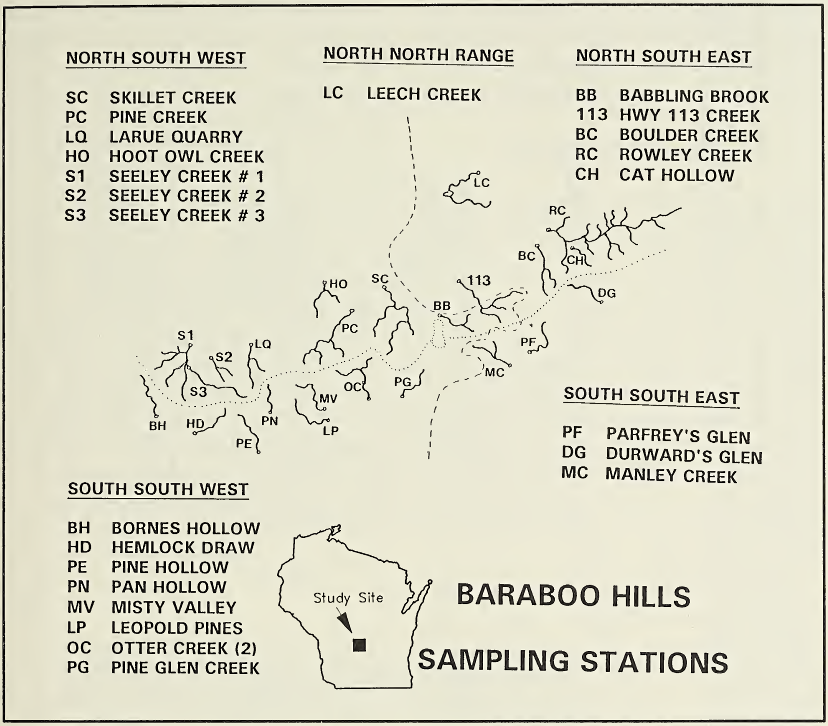

Figure 1. Location of 24 Baraboo Hills streams (Sauk and Columbia counties—see inset) relative to north-south drainage aspect as denoted by the dotted line (running from left to right) and the western advance of the glacial terminal moraine of the Green Bay lobe (after Attig and Clayton 1990) as denoted 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.

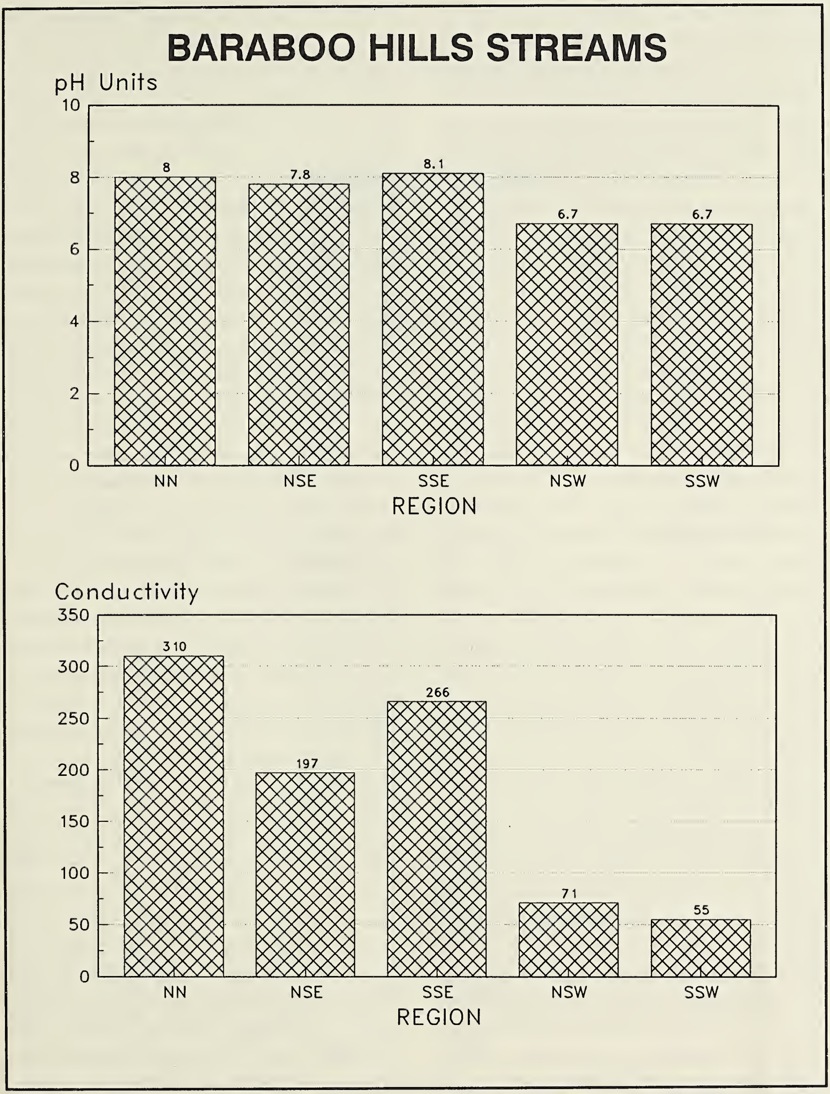

Figure 2. Mean pH (in pH units) and conductivities (in µmhos cm^{-1}) of streams within different regions of the Baraboo Hills.

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

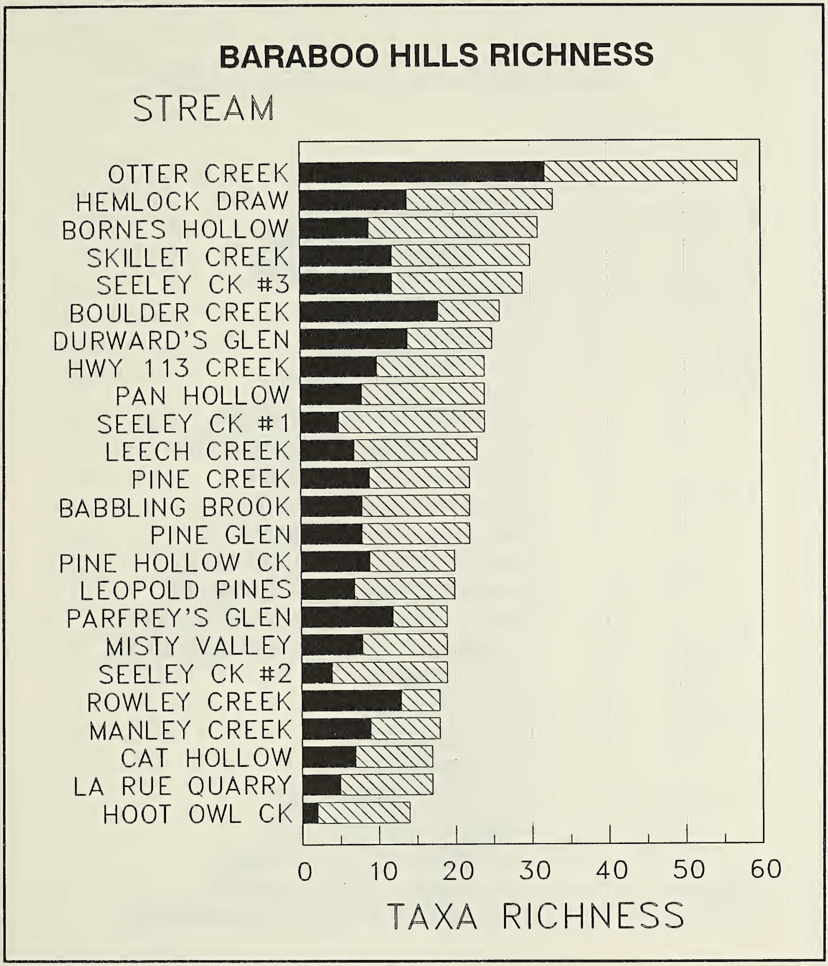

Figure 3. Total taxa richness and EPT taxa richness (dark bars) in 24 Baraboo Hills streams during April 1992. Streams are ranked from highest to lowest richness.

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

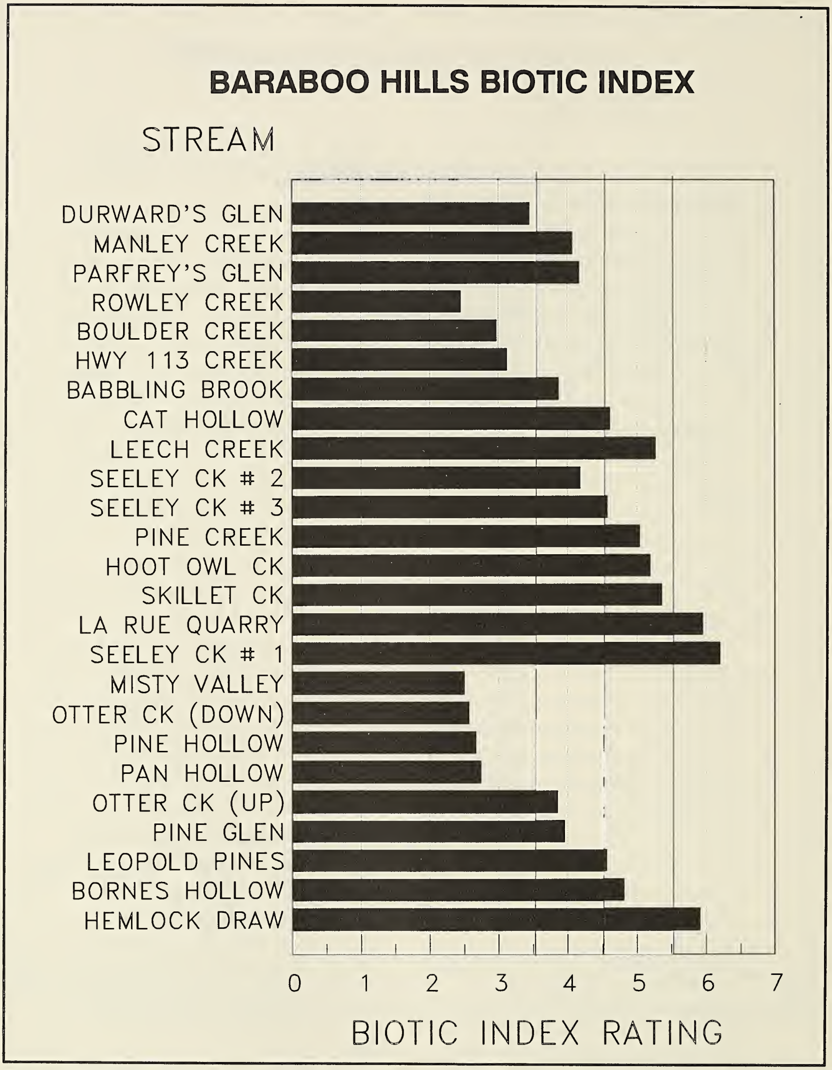

Figure 4. Biotic index values for 24 Baraboo Hills streams arranged by order within regions (SSE, NSE, NN, NSW, and SSW), based on April 1992 data (note: Otter Creek upstream and downstream data are reported separately).

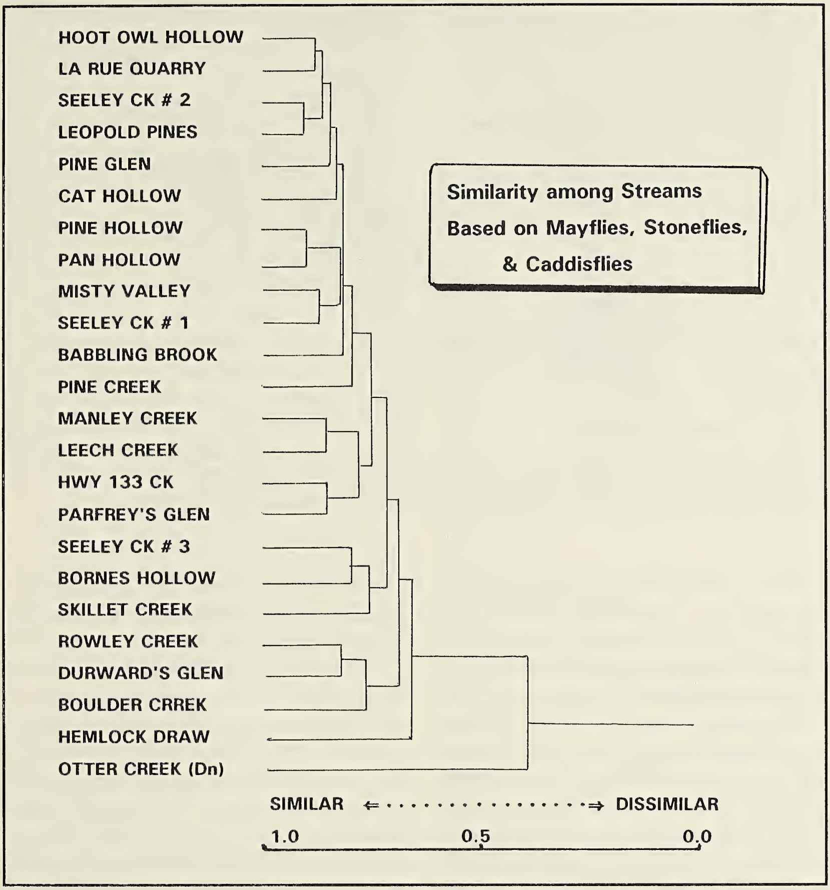

Figure 5. Cluster dendogram created by BIOSIM1 (Gonzales et al. 1993) showing degree of similarity among 24 Baraboo Hills streams based on the relative abundances of mayflies, stoneflies, and caddisflies in each stream.

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

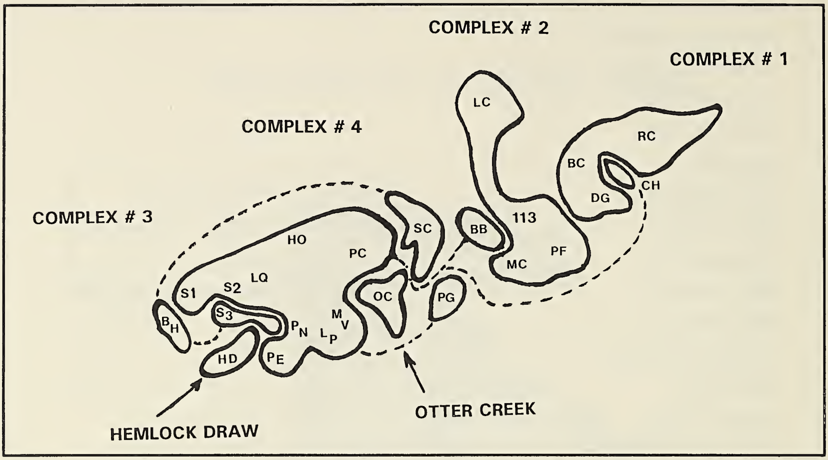

Figure 6. Complexes of streams in the Baraboo Hills based on similarities in springtime EPT fauna as determined by analysis of BIOSIM1 results shown in Figure 5.

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).

	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*
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

	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*
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.

	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
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

	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
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.

	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*
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.

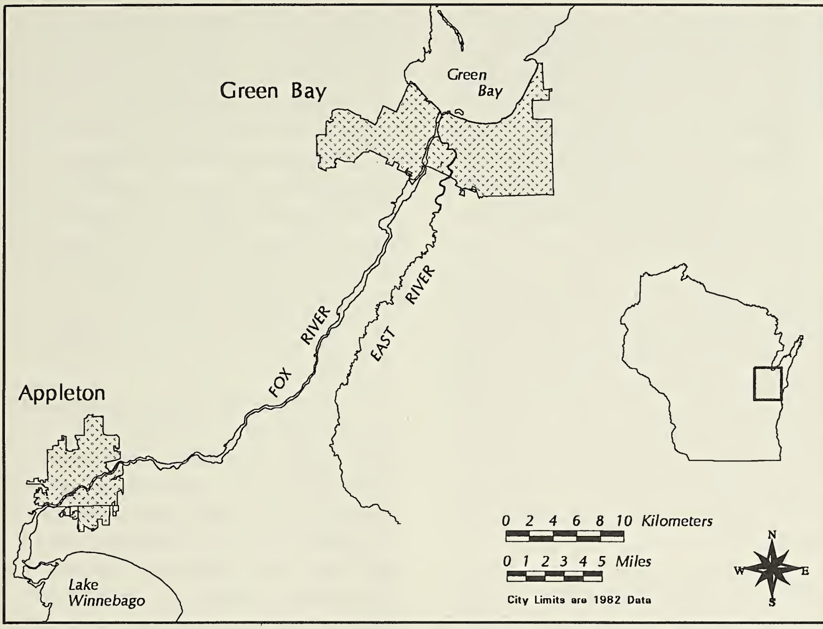

Figure 1. The lower Fox River and the East River flow from southwest to northeast. They join just before entering Green Bay, Lake Michigan. Social controversy about water pollution on these rivers has occurred through most of the twentieth century.

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-

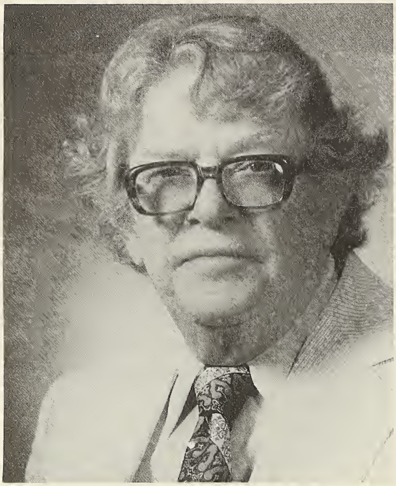

Figure 2. Attorney Meyer Cohen is recognized as the prime mover behind the creation of the first municipal sewerage works in Green Bay. Photo courtesy of the Neville Public Museum, Green Bay.

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

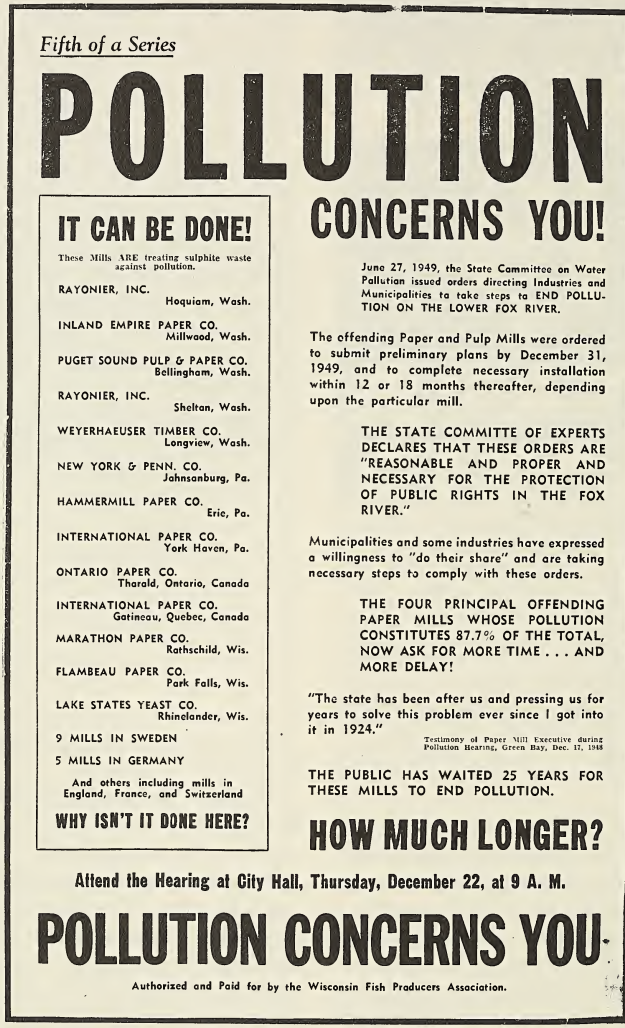

Figure 6. Advertising was one of the tactics used by the Izaak Walton League in its effort to draw public attendance to the 1948 Green Bay state hearings on Fox River pollution. Local advertising executive Harry Tubbs orchestrated an advertising and publicity campaign to elect Fred Kaftan and draw attention 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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Contents

From the Editor

"There are myriads of forms and hundreds of grasses throughout the entire earth, yet each grass and each form is the entire earth."—Dogen

This quotation from the 13th-century Japanese Soto Zen master Dogen's *Shobogenzo* (or *Treasury of the Eye of the True Dharma*), his famous collection of 100 essays, appeared on my "Little Zen Calendar" (Workman Publishing) during the month of May. It struck me as an appropriate response to the admirable selections of short fiction that appear in this special anniversary issue of *Transactions*. Somewhat like Dogen's forms and grasses, each of these fifteen stories, unique and limited in style and content, is, at the same time, a revelatory microcosm of literary artistry and of the human condition it seeks to represent.

Publication of *Wisconsin Fiction* has been timed to appear as the citizens of Wisconsin begin to celebrate the 150th anniversary of Wisconsin statehood in 1998. All who worked on the preparation of this commemorative issue did so in hope of making a worthy contribution to the celebration. In the spotlight, of course, stand the fifteen Wisconsin fiction writers themselves, whom I wish to congratulate most heartily on behalf of the Wisconsin Academy and *Transactions*. As explained in the Foreword, they were selected from a much larger contingent of Wisconsin writers who submitted their work for consideration and who, along with many others, are keeping the craft of creative writing alive and flourishing both inside and outside the geographical boundaries of our state.

Our two guest jurors, Kyoko Mori and Ron Rindo, are accomplished and recognized writers in their own right.

Ron Rindo was born in Muskego, Wisconsin, earned his Ph.D. at the University of Wisconsin Milwaukee, and currently lives in Berlin, Wisconsin. He teaches English at the University of Wisconsin Oshkosh and, beginning in July 1997, serves as Associate Dean of Humanities and Fine Arts. His two collections of short stories, *Suburban Metaphysics and Other Stories* (New Rivers Press, 1990) and *Secrets Men Keep* (New Rivers Press, 1995), individually were awarded Outstanding Achievement Recognition by the Wisconsin Library Association. Such recognition is extended to the ten books judged most outstanding among those published each year by Wisconsin writers. Ron is also a familiar figure throughout Wisconsin, in neighboring states and elsewhere, because of his frequent appearances for public readings of his works.

Kyoko Mori was born in Kobe, Japan, and has lived in the American Midwest since 1977. She, too, earned her Ph.D. at the University of Wisconsin Milwaukee. Currently, she teaches at St. Norbert College in De Pere, Wisconsin. Her award-winning first novel, *Shizuko's Daughter* (Henry Holt, 1993) was characterized by the *New York Times* as "a jewel of a book, one of those rarities that shine out only a few times in a generation." She has also published another novel, *One Bird* (Henry Holt, 1996), a book of poetry entitled *Fallout* (Tia Chucha Press, 1994), and a memoir, *The Dream of Water* (Henry Holt, 1996), written after an extended visit to her native city of Kobe. The *Los Angeles Times Book Review* found this memoir "astonishingly beautiful." Kyoko also has published individual short stories and poems in several other literary journals and magazines. Her book of personal essays, *Polite Lies*, is forthcoming from Henry Holt.

Marshall Cook, professor in the Division of Continuing Studies at the University of Wisconsin-Madison, graciously consented to act as our guest fiction editor, working with our writers after the jurors had completed their selections. Marsh studied creative writing with Wallace Stegner at Stanford, where he received his M.A. He is the author of *Writing for the Joy of It* (Will Beymer Press, 1990), is a frequent contributor to *Writer's Digest*, and edits *Creativity Connection*, a newsletter for writers and independent publishers. His articles about writing appear regularly in hundreds of magazines and have been widely anthologized. He has written short stories for several literary magazines and, just this year, published his first novel, *The Year of the Buffalo: A Novel of Love and Minor League Baseball* (Savage Press, 1997). His *Hometown Wisconsin* (Savage Press, 1994) presents vignettes of 20 small towns in Wisconsin.

The outstanding efforts of our managing editor, Patricia Duyfhuizen of the University of Wisconsin Eau Claire, also deserve special appreciation. This issue marks the fifth year of our collaboration as editors of *Transactions.* As always, I marvel at Tricia's abilities in editing and laying out such handsome final copy. Readers also may be interested to know that *Wisconsin Fiction* afforded an unusual learning experience for the students in her editing and publishing course. They worked in groups of five, running through an entire mock publishing process for the stories. This involved reading the manuscripts for minor errors, preparing an overall design for the entire anthology and a partial layout of selected stories, and even planning extra publicity and marketing efforts for the issue. Several of their ideas were adapted for the finished volume.

Finally, I extend grateful acknowledgment to Faith Miracle, editor of the *Wisconsin Academy Review,* for her valuable advice and collaboration, and to Dagny Quisling Myrah, whose art graces the covers of this issue.

Preparation of this anniversary volume has been a challenge and a joy for all of us who took part. We hope that all who read—and re-read!—this *Transactions* anthology of *Wisconsin Fiction* during Wisconsin's sesquicentennial year and in years to come will encounter "the entire earth" in these stories and find here a continuing source of delight and insight.

Bill Urbrock

Foreword

Welcome to the *Wisconsin Fiction* issue of *Transactions!* This special anthology of Wisconsin writers complements *Wisconsin Poetry,* a special *Transactions* issue edited by Bruce Taylor in 1991, and appears as the citizens of Wisconsin begin celebrations of the 150th anniversary of Wisconsin statehood (1848–1998). The publication of *Wisconsin Fiction* provides evidence that organizations such as the Wisconsin Academy of Science, Arts, and Letters, and the several organizations that have underwritten this project, are keeping the home fires burning in support of arts and letters in Wisconsin.

When *Transactions* editor William J. Urbrock and *Wisconsin Academy Review* editor Faith Miracle asked us to serve as guest jurors for this volume, we were pleased to be given the opportunity. From beginning to end, planning and carrying out the selection process has been an enjoyable and rewarding experience. In April, 1996, a news release calling for submissions was sent to newspapers and other publications across the state and to English departments at all of Wisconsin's four-year public and private universities and colleges. By September 15, 1996, a box full of submissions had accumulated in Bill Urbrock's University of Wisconsin Oshkosh office. It contained over 100 stories by 95 Wisconsin writers, sent from all corners of the state and from across the country.

When we defined what a "Wisconsin writer" was for this issue, we decided upon a geographical, rather than metaphysical, definition. Writers born here, writers born elsewhere who live here now, and writers who, regardless of birthplace, lived here for awhile, all qualified as Wisconsin writers. Many of the writers who submitted stories, and most of those whose work appears here, fit the metaphysical definition of a Wisconsin writer as well, which, to our mind, means that living here has profoundly affected how they see, know, and experience the world. "Place," as Eudora Welty has argued, "bestows on us our original awareness; and our critical powers spring up from the study of it and the growth of experience inside it. . . . It never really stops informing us, for it is forever astir, alive, changing, reflecting, like the mind of man [or woman] itself. One place comprehended can make us understand other places better." Obviously, some writers have deeper roots in Wisconsin than others, regardless of when and for how long they were planted here, yet all 95 of the fiction writers who submitted stories for this issue are new branches in a family tree whose roots take us back to tribal storytellers of Wisconsin Indian nations such as the Fox and Sac, Menominee, Ojibwa, Potawatami, and Winnebago, through pioneer writers such as Laura Ingalls Wilder, Hamlin Garland, and Zona Gale. Readers interested in Wisconsin's literary history should consult William A. Titus's *Wisconsin Writers* (1930), or Jim Stephens' impressive three-volume anthology, *The Journey Home: The Literature of Wisconsin Through Four Centuries* (1989).

Upon receipt of this box of manuscripts by Wisconsin writers, then, we went to work. We read all the submissions over the course of the next two and a half months and made independent lists of the stories each of us found strongest and liked the best. We read each manuscript at least once, many two or three times. Most of the stories were set in Wisconsin, in our cities and towns; our woods, lakes, or rivers; on farms or in suburban backyards; and it was a pleasure to see so many areas of this beautiful state set to fictional lyric. There is something special about encountering I-94, Marquette University, a Milwaukee neighborhood, Door County, Lake Superior, or the Wisconsin River in a short story; it makes you feel as if you've discovered a familiar face among strangers at a party. (Of course, some stories, including a number of those you'll find here, were set in other places.) At the end of this process, we compared lists, reread stories, and talked through each of our choices—on the telephone and over e-mail—to arrive at our final selections.

Because the names of the writers did not appear on the manuscripts, we did not know who wrote them. We admit, however, that on a couple of occasions, because of our familiarity with the work of writers we'd read before, we made some guesses. We made no attempt to try to choose a roughly equal number of stories by male and female writers (though by chance that happened)) or to give each part of the state equal representation (though that, to a lesser degree, happened also), or to choose only "Wisconsin" stories (whatever those might be). In all cases, the stories we selected simply had *something* the other stories did not—a captivating voice, perhaps; characters that startled, surprised, or delighted us; a conflict that pulled us in and held us; language so dazzling, elegant, or richly detailed, we would have gone wherever it took us. In other words, we chose the stories we felt were the strongest, and in the end, we agreed on the fifteen you'll find here. While this collection is by no means comprehensive, we believe it represents a remarkable range of quality work by many of the state's finest writers. We hope you agree.

Many readers will be delighted, as we were, by the specific regional detail in much of this work, particularly in those stories in which a Wisconsin setting is more than a simple backdrop for the story. Anthony Bukoski's lovely story, "The Korporał's Polonaise," for instance, documents Bukoski's ongoing passion for Poland and Superior, Wisconsin, the old country and the new, linked by the family history his characters so lovingly preserve. The story celebrates Polish Catholic immigrants and Superior, but it also poignantly reveals the human costs of separation from loved ones who remain an ocean, and a language, away.

The narrator of Gordon Weaver's "Saint Philomena, Pray for Us" begins his story by chronicling a series of visits to Marquette University's dental clinic in the 1950s. On each visit, before reaching the dental chair, he must pass the grisly portrait of Saint Philomena, who had all of her teeth viciously pulled from her mouth during her torturous martyrdom. Rarely has the pain of dental work been so excruciatingly rendered as it is in these opening scenes. But this story is not about dentistry; it is about faith and death and religion, and in writing about these things Weaver is clear-eyed and unflinchingly honest.

"Quick Bright Things," by Ron Wallace, takes us on a four-mile run through the farm country near Richland Center in Southwestern Wisconsin. On a hot summer day while his wife and daughters are away in Milwaukee, the protagonist Peterson—a history professor in his late forties—tries to shake off his feeling of doom by running. The details of the countryside—farm dogs, cabbage butterflies, crickets, locusts, and Queen Anne's Lace—give a rich texture to Peterson's musings about his own achievements and failures, his parents, wife, and daughters, and the "inexplicable emptiness of dread" he struggles to overcome.

The two opening chapters excerpted from Tom Joseph's novel, *Two Points*, provide more proof that detailed description can be as thrilling as action. The first chapter takes us back to June of 1934, when the narrator's grandparents, on their honeymoon, fell in love with the lakes of northern Wisconsin. The second chapter evokes the joy and restlessness the narrator feels on the first day of summer as his family prepares to head up north to their summer home.

Other stories in this volume are set far away from here, in other states and even other countries. Karen's Loeb's "How to Save a Cat and Fall in Love" is set in Florida on a sultry summer night and features June bugs, cicadas, plant life, a cat stranded in a tree, and trouble waiting to happen. The protagonist, a plant specialist scheduled to depart for Alaska in the morning, tries to win back his girlfriend's love by rescuing her cat. The story is full of humor and suspense as we experience the protagonist's dizziness caused by heights, love, confusion, and all the plant life around him.

The narrator of "Energy," by Julie King, is a former police officer shot in the head in the line of duty, now living in Texas. He is a marvelous character, full of pain and longing, displaced by bad luck and circumstances beyond his control. His wife wants a child he cannot give her, and his narration of their imperfect, yet loving, life together sparkles with his awkward tenderness. The lyrical ending is heartbreaking.

In Thomas Bontly's "December's Dreams," we find a Midwestern couple stranded in France between the Italy and London legs of the husband's sabbatical semester. The weather is much colder than expected; the Kelseys have recently been robbed during a bird-watching trip. They are at a low point of their "vacation," possibly of their marriage. The story takes us on a tour of their marriage and the husband's resentment, guilt, and frustration, into a moment of sudden joy.

"Fatimata's Ancestors," by David Tabachnick, is about a land dispute in the Guinea highlands between the Diallo family, who are nobles, and the Bah family, their former slaves. We see the action through the eyes of Sekou Traoré, chief justice of the Supreme Court who grew up in a family of wood carvers, and then through the eyes of Yacine, the patriarch of the Bah family, and his independent-minded daughter Fatimata. The politically charged plot is presented with a sense of the mysterious: witchcraft patterns drawn in the sand, a single arrow with a cock's tail, and the rich details of the food Fatimata cooks—"the richness of her sauce which sank happily into fluffy grains of fonio. . . fresh squeezed orange juice, and after dinner, cups of mint tea."

Regardless of setting, a good number of these stories are about human relationships, marriage, or loss, the subjects of much—perhaps most—contemporary short fiction published today. Martha Bergland's "Surface Tension" maps this familiar terrain beautifully, charting the interior landscape of someone thinking through his broken marriage. Even though this story is excerpted from a longer work, the main character's emotional life is fully drawn and as deep and clear as the water at the bottom of a well. "Summer Snow," by David R. Young, is about a young boy sent to his grandparents' house while his mother and father sort out the problems in their marriage. It features a wonderfully eccentric aunt and a family secret, and the narrative has the stark intensity of childhood memories.

In "Dining on Memories at the Starlite Cafe," by Marnie Krause, Vi Watkins sits down to dinner with her husband, Ed, at a diner in a small, Midwestern town. The food comes in due time, but Vi is starving for companionship and love, which she can never get from her impatient husband. The story is poignant and perceptive in its portrayal of a quietly unhappy marriage in a small town where men and women live side-by-side, never understanding each other. Seeing the sudden jovialness that transforms Ed as he talks about crops and weather with other men, Vi longs for the company of women.

Sometimes, a story's understatement strains against its dramatic subject matter, creating palpable tension that is woven through every page. Carol Sklenicka's "Putting Up Storms" is that kind of story, the title perhaps a metaphor for our often futile desire to protect those we love from harm.

In Peg Sherry's "Sand Dollar," two women friends from high school—now grandmothers—share a strained afternoon visit. The first-person narration sheds light on the history of the friendship: the two were best friends through high school and much of adult life, until the one who used to stay home, Ann, got a job and became too busy for the narrator, a high school history teacher. The narrator's nervousness, longing, and resentment ends in a gesture of grace involving a sand dollar from a vacation the two shared in Florida years earlier.

Of course, stories of relationships and loss need not be told without humor, as Margaret Benbow's and C. J. Hribal's stories prove well. In "Bachelor Party," an excerpt from *Matty's Wedding*, Hribal introduces us to

Matty, a no-nonsense Wisconsin woman who puts her grandchildren to bed, goes in search of her fiance, Luther, and finds him "sitting in a cemetery with a couple of doofuses on the eve of his wedding." One of the doofuses is Luther's son, Norbert, and Luther is blind drunk and weeping at the grave of his first wife. Hribal presents this situation with all the pathos and comedy it deserves, complete with an amateur harmonica player drunkenly accompanying a country and western song playing on the car radio.

Finally, the opening two sentences of Margaret Benbow's "Marrying Jerry" introduce us to a captivating first person voice we simply must listen to, and that voice more than lives up to its promise in this wonderful story, which delights with its language and its often wry, ironic tone.

We thank all of the writers who submitted stories for this special issue of *Transactions*, and we are pleased to have been a part of this new contribution to Wisconsin's literary heritage.

Kyoko Mori
Ron Rindo

Marnie
Krause

Dining on Memories at the Starlite Cafe

Vi Watkins, sitting across from her husband Ed in a booth at the Starlite Cafe, looked over her shoulder at Mae Collins, who was entering the restaurant with Dotty Gardner and Eleanor Webb. Vi had a smile ready in case they looked her way, but they did not. She watched Mae toss a purse ahead of her into a booth and then slide the heft she carried since childhood over the red leatherette seat. She must have said something funny because her companions laughed.

Vi envied them, though not in a begrudging way. In fact she was happy for the women, admired their independence, wishing only that she might share their company. For all I know, Vi thought, they envy me not being alone, though after considering it a moment, she doubted any of the three would put up with Ed.

Not wanting to stare, Vi settled for quick glances. She wondered if their presence was a last minute decision, or if eating out on Thursday was a matter of routine. She imagined receiving a call from Dotty. "We're going to the Starlite. Eleanor's driving, pick you up at five-thirty." "Oh, good!" Vi heard excitement in her fancied response. "I'll be ready." Mae fanned herself with her hand and said something that caused more laughter.

"Cacklin old hens." Ed frowned. "Wouldn't surprise me if they all three laid an egg."

His comment would have been comical, allowing Vi and him a share of the evening's amusement, if it weren't so mean-spirited. She pictured Ed saying the same thing to a group of his friends, how they'd laugh and think him clever, but then he'd say it differently.

Vi looked at her husband. He sat hunched over, supported by an elbow as he read the menu. The fingers of his right hand drummed silently. He was seldom still. If he wasn't tapping a nervous rhythm, he'd likely be jiggling his foot. When he drove, his head rocked from side to side as though he were working a stubborn crick from his neck.

Vi glanced at the women, and Dotty said a belated, "Hello." Vi, smiling, raised her hand. Ed paid them no mind. Instead he leaned back, crossing his arms on his chest, and called, "Rosie!"

"Ready?" The waitress pulled her order pad from her pocket as she approached.

"I want the meatloaf and mashed potatoes. Don't be stingy with the gravy."

"Green beans okay?"

"I guess."

"Vi?"

Vi studied the menu.

"C'mon, let's get going," Ed said. "Take the meatloaf."

"I don't think so," Vi said slowly. She didn't dare look at Ed but assumed there would be surprise on his face. Her usual response to his pronouncements, especially in public, was, "All right, I'll have that too," hoping to make it sound like her idea all along. But she wasn't in the mood for meatloaf. "I think I'll have the chicken."

Rosie nodded as she wrote. "Baked potato, coleslaw?"

"Yes, that will be fine," Vi said, handing over the menus.

Ed looked around the restaurant, more empty than not. Vi gave up trying to hear what the three women discussed and followed his gaze.

"Business still isn't what it was," she said.

"What's that?" Ed said. He was a small, wiry man who had a way of talking that had a bite to it, a tone that made him sound more important than he was.

"I was just noticing how few people are here."

Ed turned to look at the empty booths behind them but said nothing.

Vi hesitated, then began again. "But folks do seem to be coming back." She watched Ed arrange the sugar packets in their container and then line up the salt and pepper shakers. She waited a few moments and said, "I still think people like . . ."

"They're at Hardee's," Ed interrupted.

Vi looked down at her hands, rubbing the thumb of one hand over the knuckles of the other. She knew they were at Hardee's. She remembered when it opened out at the crossroads, close enough to town, yet within sight of travelers on Route Eight. The arrival of Wal-Mart a year later sealed the fate of Woolworth's on Main Street, where Vi had worked part-time in yard goods for almost forty years. Some Woolworth's employees were hired by Wal-Mart, but Vi, already sixty and having never learned to drive, had no way to get to the new shopping center. Ed could have taken her, but he was semi-retired by then and wanted her around the house. The demise of the five-and-dime ended what little fellowship, guarded and tentative, she'd known.

Lots of things had changed in the five years since Hardee's came to town. The bank had moved and a school was added. A bad storm uprooted many trees on Vi's street, giving her neighborhood of older homes the barren appearance of Sunset Meadows, the new area west of town where trees were no taller than shrubbery.

In this changing scene, Vi's external life remained constant while her thinking evolved. She had little opportunity to share her opinions, most of which were generated by guests on the daytime talk shows. "Bunch of freaks," Ed called them, and, yes, Vi had to admit, rather odd people were often on the programs—certainly no one she cared to live next door to. There were times the unpleasant relationships described on the shows were more than Vi cared to know about, and she'd run through the channels, seeking something less unsettling.

Recently she'd had the Starlite Cafe on her mind. Though rather deserted these past few years, it would always serve a need, Vi decided. It wasn't just that folks couldn't abide burgers and fries forever, or even that a bowl of homemade soup and a lean pork chop done up golden brown was better tasting. No, it was because places like the Starlite encouraged people to linger, enjoy another cup of coffee, share a few words with Rosie. That's what would bring them back. It was the very idea of "fast" in regard to food that Vi believed folks would tire of eventually.

She was proud of her silent convictions. To her they were like math problems done without paper. Her greatest disappointment was that she never got to ask of friend or stranger, "What do you think?"

Dotty was telling Mae and Eleanor what had happened on Regis and Kathie Lee. Vi wondered if Dotty's hearing was going, she talked so much louder than the other two.

"Wouldn't be all that carrying on if Walter was around," Ed said, referring to Mae's husband, who, needing more care than Mae could give, was in a nursing home. "Them three come to eat or what?"

Vi knew better than to defend the women. She would have felt confident saying, "I think they come for the company. For the food, too, but mostly for the company." But she didn't. Instead she said, "I heard on the television that laughter is good for digestion."

"Y'watch too much TV," Ed said. He turned to find the waitress. "More coffee over here."

Rosie refilled their cups.

"That meatloaf's taking long enough," Ed said.

"It's the chicken takes a little longer."

Ed gave Vi a look. "I figured," he said.

A grin replaced Ed's frown as he gazed beyond Vi toward the door. Vi looked behind to see the Miller brothers, Bob and Stanley, wiping their feet.

"Starting to rain," Bob said.

Before Vi could look back, Ed was up, coffee in hand, headed to where the Millers were taking seats at the counter. Vi turned to see them better. She wasn't interested in what they talked about—more than likely something to do with cars, since the Millers ran the garage—but she was always taken by the change that came over Ed in the presence of other men. Vi observed him as he spoke, animated, giving Stanley a pat on the back. She watched a bit longer as the men nodded their heads, lending authority to some minor consensus.

Vi imagined herself joining the women. It would be a nice thing to do, but would they welcome her? They never had before. In fact, nothing had changed in Vi's relationship with Mae and Dotty and Eleanor since childhood. There was a woman once, Margaret Barnes—Margaret Carter when she came to town—a pretty divorcee who took a job at Woolworth's. She was assistant manager within a year and a friend to all, including Vi. Margaret never fell in with any of the several small groups of women who cut themselves off from everyone else.

One day Margaret asked if Vi would like to take the bus to Milford to see a movie. It was *Breakfast at Tiffany's.* Even after some urging Vi said no, but Margaret teased, said Ed would never miss her, which was true. "Come on, Vi. It will do you good," Margaret said, and finally Vi agreed to go. They decided to see the early show the following Friday when Ed would be busy.

On hearing her plans, he railed about the house, slamming doors, throwing the newspaper. Vi couldn't remember what he'd said besides, "She'll be leading you by the nose in no time," and the hurtful, "What's she want with you, anyway?" In the end, Ed said no wife of his was going to go running around with a divorced woman. Vi backed out of their date, and Margaret never asked again.

"I'm sorry you're upset, Ed, but the movie sounds good, and Margaret and I are going." That's what I should have said, Vi thought, put my foot down for a change. Might have been no harder than ordering the chicken.

Vi glanced at the women and saw Mae staring at her. Vi quickly looked away. She reached for her purse and removed a date book with an attached pen. Paging through, she found a note for her dental appointment. She wrote over the time, 10:30, several times before returning the book to her handbag.

Turning toward the window, mirror-like in the growing darkness, Vi saw reflected a slight, gray-haired woman with glasses, her back as straight as a well-made seam, looking for all the world like an aged school girl waiting to be told what to do. She relaxed a bit and leaned forward, circling her cup with her hands, enjoying the coffee's warmth against her palms. She was suddenly struck by the memory of a long forgotten girlhood friend named Helen, who had come to town to stay with relatives when her mother was ill. Cancer, or maybe a nervous breakdown. Vi wasn't sure, but she knew it was serious. The girls, both shy thirteen-year-olds, became close friends. One day in early summer, with windows wide and a lilac-scented breeze stirring the curtain, they kissed—several times—soft, pleasant kisses. Vi quickly took her hands from the cup, clasping them on her lap. She looked at the women, expecting them to be staring back at her.

After a moment, Vi let her mind travel back to that day. What had prompted them to kiss? She couldn't recall, but they rarely played anything other than house. Most likely, it occurred to her now, Helen had been the father, coming or going to work. The kisses were part of the game and their innocence made Vi smile. She sipped her coffee, curious if kisses between lesbians had that tenderness about them, or if they too had a kind of urgency, ignited by desire, like that which drove Ed, making him hard and demanding.

Though it made Vi wonder, she knew she wasn't apt to learn more about it unless it was discussed on TV. And it could be, because you never knew what might turn up on Montel or Sally Jessy Raphael. Lot stranger things were talked about.

"Chicken and a baked," Rosie said, setting the order on the table, startling Vi.

She felt color rise on her cheek. "Thank you."

Ed slid into the booth, taking up his fork as the meatloaf was placed before him.

"Enjoy," Rosie said.

Vi looked at her food. She was hungry when they arrived, but the coffee had taken the edge off her appetite. She picked at the chicken, rearranging more than eating it. She watched Ed as he ate, much too fast and with conspicuous gusto, but neatly, gathering up gravy with bits of bread, spearing green beans with swift sure jabs.

Vi held her fork poised to eat, but she turned toward the darkened window, wondering what became of Helen. She might have been sickly like her mother and died young, Vi thought, or she could be alive and well, living no farther than Milford, with children and grandchildren.

What fun they'd had, sharing secrets, collecting magazine photos of Tyrone Power, sitting on the stairs, eavesdropping on the travails of *Mary Noble, Backstage Wife,* which Vi's mother listened to while doing housework. Vi remembered the ironing board creaking as Mother worked through the mounting tension of Mary Noble's complicated life. Vi and Helen, meanwhile, just out of sight, fought giggles.

Both girls had been sweet on Clifford Peterson, the young man across the street, two years older and as shy as they. Unlike most of the boys, he was polite and studious, with a talent for drawing. In high school Vi had been hopelessly in love with Clifford. He never came back after going away to school and settling in Kansas City, where, Vi once heard, he designed greeting cards. Clifford's kisses would have had that gentle quality, Vi decided. They would have been tendered with a sensitive kind of love.

Her memories surprised her, coming as they did, unbidden, pleasantly recalled, yet leaving her with a sense of sadness. Vi looked around the Starlite, at its handful of customers. She found it appropriate somehow, though she didn't know why, that her remembrances were being rekindled there.

"Git movin," Ed said, reaching for the last dinner roll in the basket between them, "I'm near half done."

Vi took a bit of coleslaw, but its vinegary taste, which normally didn't displease her, tonight was strong and bitter. She sipped her water, speculating on who she might be if she'd moved on, like Margaret and Helen and Clifford, left her small community where, it occurred to her now, others only saw people as they'd always been.

Laughter from Mae, Dotty and Eleanor, joined by Rosie, broke Vi's reverie. She noticed Ed look over at the women and shake his head. Eating was serious business to him. Vi knew he was getting irritated and would likely suffer from an upset stomach later on.

When he finished, Ed laid his fork on the table next to his plate, just as shiny, Vi noted, as a dish set before a hungry pup.

"Why'd you even order?" he said. "Looks like you didn't eat nothin."

"I'll take it home. Maybe you'll like it later."

"Yeah, well, forget the coleslaw."

Rosie returned with coffee. Seeing Vi's dinner, she said, "Anything wrong?"

"Just ain't hungry," Ed said.

"I'd like to take it with me."

"Sure. I'll get a container."

"Bring a slice of apple pie while you're at it," Ed said.

As he ate his dessert, Vi again tried to see herself in different circumstances. She couldn't, but it didn't matter. It was too late now. And compared to talk show women, who were battered or suffered men who were drug users or carriers of all manner of disease, her complaints were trivial. She knew Ed couldn't get along without her, yet she had no sense of identity apart from her own; no feeling of worth or importance fostered by what she saw reflected in the eyes of others.

It's what love should do, Vi thought. Real love, the sort one heart feels from another. She'd long ago given up on the storybook variety she believed in and hoped for as a young woman. It hadn't survived courtship, a period of few romantic memories. Though there had been an incident that held great promise; recalling it still warmed her. It was the day, nearly fifty years ago, when Ed lifted her down from the Ferris wheel carriage at the county fair. Two of his friends standing nearby hooted. "Go on," Ed said good-naturedly, with a wave. Then, red-faced, he took Vi's hand as they stepped from the platform. How happy she had been at that moment.

Ed picked up the last of the pie crust and popped it into his mouth. He finished his coffee, pulled a paper napkin from the table dispenser, and vigorously wiped his lips and chin. He took another napkin for his hands, then used it to sweep together the crumbs around his plate. As Vi gathered her things, she noticed him breathe deeply and sigh. She thought of Pepto-Bismol, making a mental note to check the cupboard, to see they weren't running low.

C. J. Hribal

Bachelor Party

Excerpt from *Matty's Wedding*, a novel

Matty has a pretty good idea of where Luther is. While she is helping put the boys down at Rose's—Charlie and Bill cling to her neck, ask for stories, water, a trip to the bathroom, a song, *please, Gramma, oh please oh please oh please oh please oh please oh please!*—she imagines Luther at the Y-Go-By. He's keeping an eye on his son Norbert, who's burst in with Byron Joe and Vernon Haight, Jr. and Leo Baumgarten, Augsbury's Mount Rushmore of Indolence.

Luther would be there because he believes he can keep Norbert out of trouble by keeping him company. He's been doing this for a week now. He sits at the bar for an hour or three while the Mount Rushmore of Indolence shoot pool and talk dirty, and when he's heard enough, he says, "Come on home, son," as though the words "home" and "son" meant anything to Norbert. And Norbert says, "Run along, Dad. I'll be along directly." And the next day, when Luther's already up and running a hose over the concrete barn slab, Vernon Haight, Jr.'s pickup or Byron Joe's party van—a phone company panel truck with an easy chair and a sofa bed thrown in back—comes wobbling past, on their way to Vernon, Jr.'s to sleep away the previous evening. The Purple Palace on Highway 10 has striptease till three, and the private parties go on a lot longer than that. Four young bucks with a wad of money could arrange for themselves quite an evening. Norbert has already said he'd like to take Luther there for his bachelor party. Luther rarely drinks, so even his feeble attempts at keeping up with his son result in his weaving into the house like a drugged spider.

The boys are down and Millie's forehead has been kissed—she needs one Mmmwaaa! right over each eye before she'll go to sleep—and Matty's stirring up pitchers of lemonade and iced tea for the family breakfast the next morning. Tonight, Matty announces to Rose as she stirs, tonight she's going after him.

Rose, from the living room, calls out seriously, "Be careful, Mom."

"Be careful?" Matty laughs. "Dear, I'm going to a bar, not a crack house." She shoves a jar of pickles aside on the top shelf of the refrigerator to make room for the iced tea.

"I know, Mom, but you seem so, I don't know, intense, earnest. You practically drilled Millie with those kisses."

"Ol' howitzer lips."

"You know what I mean. I just think, I mean, I'm not saying to be careful on account of your safety, okay?"

"Okay. You want I should put tea on for you?" Rose is sitting in her easy chair with the lift seat so she can go from that to her wheelchair. Her crutches are behind the chair by the window.

"No, I'll be okay. I'm just going to set here and let the beer percolate through me. If I drink any tea, Joe'll come home and find me floating in my own juices."

"He might like that."

"Mother!"

Matty leans over slightly to give Rose a kiss above each eyebrow. "There you go, dear. If the boys or Millie wake up, you have some extras."

"Mom, be careful."

"I will, dear. Honestly, I will."

Her good mood lasts until she's in her own driveway—Luther's driveway, really—putting on her turn indicator to signal a left into town (funny how even going out of her own driveway she puts on her turn indicator—this in a town where nobody signals because most everybody knows where you're going anyway). She had driven home from Rose's just to check if he's there. But the house lights are off, as are the barn lights, and it's only the purplish white halo of the mercury lamp high on its pole that lets you know you're in a circle of civilization, a safe spot on the edge of the prairie. She decides, shifting into second and then third, that if she finds Luther tipsy at the Y-Go-By, she will be furious. She'll sit with him for a moment, order a club soda maybe, and then say under her breath, the words cutting over her teeth so they reach him raggedly, grinding his ears raw like sandpaper, "I'm not going to embarrass you by screaming, but you get your fat ass off this barstool immediately and come home or there's going to be hell to pay forever." Then she'll say brightly, "Thank you, dear. I'll see you at the house in a while, okay?" and leave separately, her purse clutched under her armpit.

But she barely goes a hundred yards when she crosses a rise near the end of Luther's property and sees lights in the cemetery. She stops, her elbow out the window, and, over the engine's idling, hears the plaintive, off-key wail of a harmonica wielded by an amateur.

She drives down another quarter-mile to the stone and wrought iron entrance gate and takes the winding gravel drive back to where she saw the lights. It's near where Marion, Luther's first wife, is buried. There's a small fire there, banked between two headstones. Byron Joe Gunther's white whale is there, the phone company logo spray-painted over with brown paint. It's his lights that are on and his car radio, tuned to the country and western station in Appleton. A honey-husky woman's voice is singing a very slow, tumbling version of "I'm So Lonesome I Could Cry," accompanied on the radio by not much more than a slow-thrumming bass and in the cemetery by Byron Joe's inept harmonica playing. A cat with its tail pulled would produce less reedier wails.

Byron Joe is slouched against the van's grillwork, his belly hugely pregnant with hops, his green sleeveless T-shirt not quite covering the swell of belly flesh as it cascades like a hanging snowdrift over his jean tops. He cuts his eyes at Matty and tries running a trill, but the effect is more like the plaintive, saggy noise you might get from hurling a tabby at an accordion.

A little ways off sit Luther and Norbert, their feet splayed, bottles rising from between their thighs. Norbert's feeding the fire. It crackles like static. Luther's face is streaked with tears; his eyes are glassy, gleaming. His truck's behind him. In the three years since Herbert Tessen courted and lost her, the word he painted on the driver's door panel hasn't faded quite like the rest of the finish. The truck's a creamy, pastel green, the color of a doctor's waiting room, and the dribbly WHORE Herbert painted stands out in ghostly forest green. You can barely see it in daylight, but with Byron Joe's headlights on it, it's like the name on somebody's boat: SEA WITCH or CASSIE'S FOLLY or some other hideous monstrosity done up in reflective black and gold letters. Why would anyone do such a thing? Matty wonders, but the tableau of misery spread out before her would seem to indicate people are capable of just about any stupidity. Remembering her two evenings with Porter Atwood when Ben was dying, she hastens to include herself, but that was at the height of her grief. Luther is sitting in a cemetery with a couple of doofuses on the eve of his wedding.

Byron Joe, true to form, cuts off his wailing and belches lewdly.

"Evenin' again, Matty."

"Good evening, Byron. Practicing, are we?"

He nods towards his van and the husky singing emanating from the radio. "If she can do it, I can do it. It's never too late to be somebody in the music business. Maybe in a few weeks I'll shy away to L.A. and be somebody. You wait and see." In his beefy, lard-like hands the harmonica looks like one of those tin pipes you get in Cracker Jacks. It sounds like it, too.

Unless he's trying to raise the dead, he's chosen a curious career path: town loaf and inveterate trouble-maker makes good in L.A. as harmonica player.

But Byron Joe is too big and frequently too violently drunk to make fun of. "You keep practicing, Byron. You'll catch somebody's eye eventually."

"Caught the eye, the shoulder, the whole damn thing already," Byron Joe says. He cocks his head towards his van a second time and calls, "Louise? You ready?"

A giggle in reply from the van's insides. "Almost, Ronnie." It's not a voice Matty recognizes.

"We were figurin' on doing this at your wedding," Byron says, and tunelessly approximates "Here Comes the Bride" on his harmonica.

A blond woman in a Lincoln green teddy and a feathered Peter Pan hat comes out the back of the van. Her heels wobble in the soft earth; she's young, maybe nineteen. "Oh, hi, there," she says when she catches sight of Matty. "I'm Louise. I'm a dancer."

"You are indeed," Byron Joe says and razzes on the harmonica. Louise recognizes this is not the time or place for harmonica razzing or impromptu dancing. She lets her eyes fall. "Ronnie said I could change here and he'd get me back in time for my next show. I'm seventh at the Purple Palace, shows at three and ten," she announces rapidly, like she's listened to and believed too many carnival barkers. Then she adds, "We didn't mean any harm. Ronnie's always pulling some stunt. He says I'm prettiest when I look to be in trouble." She waits a second, and then her eyes lift. "Are we in trouble?"

Matty shakes her head. "I'd like to put on a sweater at least, Ronnie," Louise says, and disappears inside the van. Through all of this Luther and Norbert have not said one word. Occasionally a stick cracks, and Norbert places the two ends in the fire. Shaking the sticks, he sends up a gussy of miniature fireworks. They look like orange fireflies rising in squadron.

"Evenin', Matty," Norbert finally says. His intonation is even flatter than Byron's.

"Good evening, Norbert. Have you and your father been out here all day? If I didn't know better, I'd say you were." There's a pile of brown and green bottles in the gap between them. Norbert removes a new one from the case he's leaning against, and the empty nestles against its brethren with a friendly clink.

"Pretty much. Me and Byron left for a bit to see about the Round 'Em Up and fetch Louise between shows, but otherwise we've been keeping watch with Luther here."

"Watch?"

"He said he needed to get away from the goings on at his place. Or your place. Or whatever it is. He said he needed to think. Maybe he needs to convene with Ma's spirit. Or Dana's. He's been talking about that, too.

Who the fuck knows?" He takes a glug from his Leinenkugel's and belches, a single pop of air that doubles as punctuation.

Luther sits like a stone. He's staring straight out at the space between the van and the truck, where it's purply black and the trees are greenly dark and the gravesites look like baby teeth. It's a crowded space that's also amazingly empty. Luther seems mesmerized. His cheeks are wet from crying, and a fly crawls around an earhole. Matty squats on her haunches, then places a hand on his shoulders. "Luther?" she says as though he were asleep.

Luther slowly turns his head. His eyes are not blinking. The alcohol must have short-circuited his normal bodily functions. When he turns his head, it's like he's a robot. The voice, though, thick and gummy, is certainly, plaintively Luther's.

"Marion says it's okay for us to marry. It's okay, she says. We can. Marry, that is. It's okay, Matty. Really. We can. We can marry."

Even though he uses her name, it doesn't seem likely he's seeing her. Perhaps when she first came up and Byron Joe and Norbert greeted her, he heard the familiar bent of the syllables and the familiar stayed. But that's not recognition. It's pressing something down in putty, meaningless. Does the putty know it's received the impression? Does it know it's stretched, accommodated, given way? Of course not. Another of Luther's body functions is on vacation. He is—Matty shudders with revulsion—blind drunk.

"Jesus, Luther, Jesus." She sits in the thick green carpet to stroke his forehead. It's clammy. It's been hot all day, and the air is finally cooling off, the water going out of it like a wrung washcloth. Almost immediately she can feel the dew soaking into the seat of her sundress. Then she smells something vinegary and acrid. She feels between his legs. Yes, he's peed himself. Probably a belatedly inaccurate response to what he'd have liked to have done when Byron first fetched Louise. Still another vacationing body part. He pees when he wants to come. She only hopes he doesn't lose control of his bowels. When she was little her own mother was quite old, and as she slipped into senility, cleaning up after her incontinence became a daily, horrifying ritual. She has an early glimmer of what future life with Luther might be like, and it smells like pee.

"Jesus, Luther," she repeats. "Jesus. Norbert, help me here. Help me get him up. Byron?"

Byron's nowhere to be seen. But the white whale begins to rock a little, and over the twangy up-tempo Dolly Parton number, Louise's bell-like voice is ringing like a cheerleader's until the van is shimmying like an unbalanced washing machine.

They watch for a moment, dumbfounded. Fireflies are lighting up outside the ring of the campfire like delinquent flares. Finally Matty says, "I need to get him home, Norbert. Will you lend me a hand?"

Once Luther's on his feet, he moves as though underwater. He has the deliberate movements of one learning to walk again. Of one who remembers he used to remember, but isn't sure you need to remember or simply do. The memory itself is maddening. As they pull even with the van, something else—the guttural gruntings and exertions of Byron—is weaving itself into Louise's cheering. If a grossly overweight salmon urging itself upstream were capable of sound, this would be its noise.

Even leading the somnabulatory Luther, Matty can't stop herself from shouting, "Byron! Give her the top!" And then they hear a sound like the slap of water underneath a pier, then a long grunted sigh, and they know Byron's spent himself and is instantly asleep. Matty only hopes Louise was either on top or is able to wriggle out from beneath his immenseness. She can imagine the poor girl there all night, trying just to draw an even breath. But then there's a metallic rustling from inside the van, the sound of tools being scraped or dropped across metal, the inside light comes on, and they can see Louise struggling into a jean jacket. Then she's holding up a gargantuan pair of jeans and is rifling the pockets.

Matty doesn't need to see anymore. Louise will get what she needs.

And then they are past her, past him, and it is only the varieties of black and green dark and the glow of the tombstones and the incandescence of the fireflies through which they move.

He pees himself again as she's leading him up the porch steps. Norbert helps her with Luther in the cemetery as far as the car door and then says he needs to help Louise get back to work. Uh huh, Matty says. She can imagine what that entails. Byron's is not the only pair of pants Louise will be looking through this evening.

Once Luther's splayed out in the back seat, a blanket under him to protect the fabric, she drives him straight home. No way is she going back to the Round 'Em Up. Mercifully, the children are already gathered and gone. And she's sure the adults have given up waiting as well. But then she looks up, and her oldest son, Matthew, is sitting on the porch swing, his position marked by the glow of his cigarette. When he inhales, it's like a new kind of lightning bug. She opens the rear door and gets Luther out. Bodily functions aside, he is more or less ambulatory, and Matty's doing more leading now, less yanking and tugging. She means to get Luther into the tub, clothes and all, and soak the stench of beer and urine out of him.

"I see you found him."

Between gritted teeth, "Ye-a-a-ssss."

"I see he's quite a prize." A half beat and then he says, "Mom."

They are on the porch proper now. The lightning bugs are still out, flitting freely over the grass. Matty thinks of men with miniature jet packs, trying not to collide. She decides that most men already have them.

"Matthew, come to the point." The exasperation in her voice is weighted with fatigue. She was prepared to defend herself and Luther against any objections by her children, but the onslaught, the rebuke is so slight, it's like a feather landing at just the right moment on the heights of the walls of Jericho. Matty sees how slight and fragile her defenses are, how frantically hollow. If he were to say one more thing, she might burst into tears the way Leona Griemerts does at any function that requires wailing.

Matthew uncrosses his legs and strides over to her. He props open the screen door with a brick and, with her leading, propels Luther from behind into the living room and up the stairs into the bathroom with the tub. He knows where she wants him. They get his shoes off and one and a half socks. They plop him down and begin running the water on top of him. He's slumped asleep, and Matty turns the shower head so the spray hits nicely into his chest. A long guttural "OH!" escapes him, but all he does is turn on his side so the spray hits him in back, in his ribcage, just below the shoulder. She flips the tub lever to let it fill, then pulls the curtains so she won't have to look at him.

On the front porch Matty waits for Matthew to back out his station wagon. They are not going to talk about this. There's this understanding between them. Matty won't ask him about his evening—she wonders if at any point his old flame Rita Sabo made an appearance—if he won't ask her about hers. His elbow V's out the door. It's the gesture of driving common in her family. Even in winter Keillors drive with their elbows V'd, an unconscious ease of being behind a wheel. At least there's that. In the mechanical world, at least, they are at ease.

"Ma," he says before he drives the three point eight miles to Amanda's, where his wife Angie is waiting. "Go ahead and marry the guy. A man who'd do this to you knowing what you'd be like in the morning is either too brave, too unquestionably stupid to worry about, or too weak to give you any trouble. You can easily handle him, Ma. Marry him. He beats the stuffing out of Daddy in the weakness department."

Karen Loeb

How to Save a Cat and Fall in Love

It's one of those sultry Florida nights, hard to think of sleeping, hard to enjoy the beer that has formed a puddle around the base of the bottle. The suffocating weather is approaching intolerable when your beer bottle sweats this late at night. The June bugs are crashing and buzzing against the porch screen. All is not right with the world. Which means Greta isn't here on the porch. Mike doesn't know exactly why that is. And now he can't do much investigating because tomorrow he leaves for Alaska to study summer plant life. He last saw Greta a week ago at her place: the deluxe Snell Isle apartments where he thought he was staying over. He had every reason to assume this because they had been staying over at each other's places for two months. *"Your bachelor pad,"* she said, her voice curling in derision when they had what Mike thought was a spat and now realizes was probably more like a civil war.

"You're not reliable," she said. "Your work comes first, and now I think it's someone else that comes first."

"I told you," he explained, pinching the bridge of his nose under his wire-rimmed glasses, "that the woman who answered the phone that time was a neighbor."

It was the truth. Valerie is a neighbor. She lives across the alley with a passel of grown sons who ride motorcycles and all-terrain vehicles and cultivate pit-bulls, and a husband—Warren? Wally? Wacky?—who measures people's floors for linoleum and then goes on a bender before he can cut and cement it. No wonder Valerie wanders the neighborhood in desperation and brings pies over to Mike's house. Mike can't help it if she fixes herself up to look pretty when she comes over. At forty-five, fifteen years more than Mike, she has red hair that he guesses is still her natural color and freckles even. The one time Greta met her, Valerie came over to Mike's bungalow wearing short shorts and a tube top. When they had their fight, Greta brought that up.

"You didn't have to ask her in," she said.

"She's my neighbor—she brought us a dessert."

"I somehow don't think she intended the French silk pie for me," Greta said. *"She was practically naked."*

"What are you saying?" Mike asked.

"I'm saying that you're not making things clear. That here we are involved, and you let this woman in, and an hour later I realize she's not going to leave. When I say, 'Mike, how about driving me home,' you remind me that I have my own car at your house. I drive home with the memory of you both sitting on the couch at one in the morning."

Mike takes a swallow of beer. In front of the porch, the rattling in the bushes commences. It's the nightly run of the possum family. He leans forward, glimpsing these animals that share his yard. He sinks back against the canvas in the director's chair, missing Greta, wanting her to be in the chair opposite his so he can reach over and touch the smooth skin on her face and twist his fingers through her curly spring-loaded hair that nestles on her head like an exotic fern, *Asparagus plumosus*, weaving around his heart and soul.

The phone rings. His muscles tense, but he doesn't move to answer it just inside the door. After the machine beeps, a woman's voice comes on with a message. It's Greta, talking about her cat, Jonquil. It's one reason he likes her. She has a cat named after a plant: *Narcissus jonquilla*.

He leaps for the phone, not knowing he had that much leap left in him at this hour. His hand plucks the receiver. She's still there. He finds that he's extraordinarily happy, giddy, that her voice is wafting into his ear. At first, he doesn't hear what she's saying. He's grooving on the lilts, the intonations.

"Mike, is that you or the machine?"

"Me," he says. "What's this about Jonquil?"

He hears a catch in her voice when she tells him the cat hasn't come home and asks what she should do. Would he come over and help her search?

He thinks of the plane he has to catch from the Tampa airport in the morning and determines that he probably isn't destined to get much sleep.

"Please," she says in a wispy voice.

"I'll get there as soon as I can."

It's a half-hour drive through city streets in St. Pete to her apartment. The back end of his station wagon is open—tied down over the extension ladder he grabbed from the garage. Lost cats and ladders seem like a good combination. Besides, his father, who was Mr. Fix-it himself, always told him he'd never go wrong if he had a ladder with him at all times.

They're walking around the yard, acreage really, which surrounds Greta's huge Spanish-style apartment building. The moon lights their way in silvery patches. Greta's hair is caught in clumps by each ear, and a crooked part runs up the back of her head. She's wearing perfume with a wild flower smell that is causing Mike to lose his reasoning. They've been hiking in the yard for a half hour, whistling and calling, "Jon-quil, Jon-quil, here kitty kitty."

"Thanks for coming over," she says. They stop under a banyan tree, *Ficus benghalenis.* A streetlight from the alley makes her white T-shirt and shorts glimmer. "I missed you," she says. "I thought it was time to end this stalemate."

"I'm glad you called," Mike tells her. "I'm sorry you were so upset with me." His hand on her shoulder eases her toward him. She presses into him, her breasts flattening against his chest, her bare knees touching below his bare knees. She feels electric to him, and if he were completely honest, he'd admit he doesn't give a damn about her cat. He's glad the cat is missing if that's what it took for her to call. He leans down to kiss her.

"Wait," she says. "What's that?"

"What's what?" He tries for the kiss, but she leans back.

"Listen."

All Mike can hear are the crickets and the million other insects rustling about.

"It's Jonquil. I heard her."

"Are you sure? It could have been the wind," he says with hope crowding his voice. The moment is over, and he feels desolate as she backs away.

She calls in cooing tones, "Jonquil, Jonquil, Jonquil."

Her persistence pays off. A loud meow startles them into holding hands for a second. Mike takes this as a good sign even though Greta lets go quickly. "Where is she?" she asks.

"Over that way." They walk quietly through the grass, listening. Another meow. This time it's overhead.

"There she is, Mike. Oh, Jonquil, you poor kitty." She looks up, and he follows her gaze. There's the cat, its puffy white fur visible for miles, probably. It's a calico because of token orange and black splotches, but it's mostly white. A true glow-in-the-dark cat.

"Jonquil," Greta calls. The cat meows in answer.

She's perched on a thin branch of a toothpick of an avocado tree, *Persea americana,* about twenty to twenty-five feet up, Mike estimates, which is just great because his ladder only extends to fifteen feet. Already he imagines himself shimmying up the rest of the way, grabbing at Jonquil, who scoots just out of his reach, then losing his grip and falling to the soft

Bermuda grass below, *Cynodon dactylon,* which, when he hits it, will feel like ice picks. As he lies there numb, with the pain of many broken bones, he will see, through glazed-over eyes, a large white clump moving downward through the branches. He knows this is his fate, and he also knows that, if he wants the woman, he has to go after the cat.

"Can't we call the fire department?" Greta asks.

"Sorry to disillusion you, but they won't rescue cats. It's an urban myth, like alligators breeding in sewers and coming up through toilets. Wait here and talk to Jonquil a minute. I HAVE A LADDER!" He bounds off, his long legs sprinting over the grass. "Get the ladder, catch the cat," he chants. He's elated that Greta is talking to him but dreading the climb because he has never liked being more than a few feet off the ground.

Now he's on the ladder, which is stretched to the max. If he doesn't look down, maybe the vertigo won't set in. He's peering into the shining, saucer eyes of Jonquil, who is regarding him coolly from her branch five feet above. "Come on, Jonquil, just a little closer," he pleads, reaching his long arm as far as it will go, which is not far enough. Jonquil meows but doesn't move. "Jonquil, you feline fiend," he says in what he hopes are dulcet tones, "get your furry rat-chasing hide down here, dammit." He hopes Greta didn't hear.

He descends half-way. Greta stands by the ladder, her face crimped in distress. "I've got an idea," he announces. Until he says it, he hasn't a clue of what to do next, but it sounds good and it buys time. "Get the basket," he says. "You know, the one you have your *Ficus carica,* your fig plant in. I'll stay here and talk to Jonquil." She gives him a confused look. "The plan is . . . " He pauses. "To get the cat to jump into the basket." She doesn't protest as she turns and runs toward the building.

Ten minutes later she's handing up to him the three-foot-tall basket shaped like a tube. He grasps the straw handle on the side and climbs higher, clucking to the cat.

As he approaches with the basket, Jonquil does something maddening. She edges back on the branch, so she's no longer directly above him. Now she's to the right, regarding Mike with terror, and, he suspects, some amusement. He reaches the basket up and over, leaning as much as he dares, his heart pumping, calling to Greta, "Keep the ladder steady."

The basket reaches within two feet. If this plan works, and suddenly Mike thinks it will because the cat is perking up her ears and extending her neck, then she will jump into the basket. What he has just realized and Greta has no knowledge of yet, is that when the cat jumps, Mike will be so off-balance that he won't be able to keep hold of the basket. It will fall, feline cargo and all, to the ground. He's not sure how to tell her this and maintain his balance and concentration, so he continues talking to Jonquil. "Come on, kitty, pretty kitty. Jump, you rascal."

"Jon-quillll," Greta calls, anguish in her voice.

"Hold the ladder," he hollers as the cat jumps with a heavy, well-fed thud straight to the bottom of the basket. It jolts out of his hands and plunges through the skinny branches, crashing to the ground.

"Ohhhh, my poooor cat," Greta wails. She lets go of the ladder, causing it to sway for a moment, sending dizzy waves through Mike, who's cautiously climbing down.

Once on terra firma he feels much better. Jonquil is crouching in the basket, which is on its side. Greta has to reach in and disengage her claw by claw. They're able to determine that the cat is traumatized but uninjured. Greta holds her large bundle of cat like a trophy. The trophy burrows its head into the crook of Greta's arm and refuses to look at her rescuer.

"I don't know what upset me more, the cat in the tree, or the cat careening to earth," she says.

"I would have lost my balance," Mike explains. "I couldn't hold on to the basket."

"I realize that," she says. "I didn't know if you knew that, and I know Jonquil didn't know." They laugh. "Thanks so much. I know you have the big Alaska trip, and it was asking a lot of you to come over. Jonquil thanks you, too."

"She's a sweetheart," Mike lies, stroking her back, feeling skin twitch beneath fur.

"What time is your flight?"

"The shuttle comes to my house at six a.m."

"I don't have my watch. What time is it?"

Mike glances at his wrist. The phosphorescent dial is lit up like a landing strip. "It's almost three-thirty. Come on, I'll walk you to your door." He grabs the basket and puts his arm around her shoulder and hugs her, and the cat, to him as they walk toward the building. "You'll probably be able to sleep in and do a half-day tomorrow," he says.

"No way. I have four new clients to interview in the morning. My boss doesn't expect alert, but he does expect a body. Besides, you can't blow off people who have appointments."

"They're not like plants," Mike says. They're at her door. "Why don't you put the cat inside," he suggests.

"Good idea." She bends down, lets the cat cascade out of her arms, and stands, facing him. "I'm glad we're talking," she says.

"Me, too. I missed you." They fit easily into each other's arms and kiss for a long moment. "If I don't leave this instant," he tells her, "I'll do something I'll regret, like miss the shuttle." They kiss again.

"Good trip," she says softly, brushing his chin with the back of her hand.

"I'll call you next week. Nope, I'll call you from the tundra mid-week."

"I'll look forward to it."

When she closes the door, he can hear her talking to Jonquil, who's yowling about the momentary desertion.

He enjoys the drive home through the empty streets of St. Pete, still tasting Greta's sweet lips on his. He smiles when he thinks of her prima dona roomie, Jonquil. The *Palmaceae* are alive with wind, the fronds swishing and the trunks bending slightly.

At home, he's barely inside when he hears a knocking at the back door. As he walks through the darkened house, he figures he has enough time for a shower and shave and about an hour to relax. He opens the door to find his neighbor, Valerie, her hand on the frame. He's vaguely annoyed and is about to tell her how rushed he is, but even in the shadows, he can see that her red hair is uncombed and that she has a black eye.

"You didn't get that walking into a cupboard," he says.

"No," she agrees. "I didn't."

He moves aside for her to come in. It's the first time she's visited without bringing a pie or cake. With his hand on her back, he guides her through the house. His feelings for Greta rest neatly in his heart, right below the wooden button on his shirt pocket. In the unlit bedroom he coils his arms around Valerie, momentarily bemused about how this could be happening. But she's here and needs him, and he isn't going to have time to sleep anyway.

Martha Bergland

Surface Tension

A novel excerpt

One

When he hung up the phone the darkness had a new quality. Jack sat up in bed and watched as the darkness was slowly revealed to be jumping colors. Not just behind his eyelids but out there, too. The banging of molecules against each other seemed visible to him. But why hadn't it been clear to him from the beginning, when anyone who looks with two eyes can see that darkness is made of motion? Jack sat in the middle at the head of their bed, like some king he had read about who received his subjects in his bed chamber. But in the dark? There's been a lot of kings. Some king must have sat like this, only it was people around him, invisible in the dark, indistinguishable from the other jumping colors. No subjects here. No subject to contemplate but the dancing silence and darkness which Jack sat watching.

Everything that had seemed still or solid or not there at all now seemed liquid, active, full of motion and color, and, though he sat quiet in his same bed and though he felt calmed somehow by his earlier unexpected tears, he felt himself to be no longer a man whole and solid but made of millions of tiny motions bounded only temporarily by the power of his will, which at this moment felt no stronger than the surface tension that held water over the rim of a glass. He felt that he would soon be overpowered by the tiny, mass decisions of amoebae and cells and viruses and other inhabitants whose names he didn't know—bright pointillist things that added up accidentally to be Jack Hawn in Green Bay, Wisconsin. For a long time he was unable to move. He was afraid that what he was would spill out and that he would become someone else.

But why? Jack knew himself to be a reasonable man. The only thing that had happened to him, he told himself, was that his wife had called and said she wasn't coming back. This happened to men all the time. And Janet hadn't even really left him. She'd said she would stay there in Illinois, in Half Moon, to be where they grew up. She'd just said she thought they both should be there. She loved him, she said. And she was not there to be with his brother again. She was going to live in the old hotel where her dad lived. Jack believed her, believed that she was not going back to Carl. She'd asked *Jack* to go back to the farm and live with Carl, like brothers again, she'd said. You need your brother back. And Carl needs you. His drinking is bad; the farm is in bad shape. All Janet wants is for us to come back where we started from, to come full circle, to come home.

Jack sat very still. The motion was outside of him and inside of him too, the colors and bright unpredictable motion. All his reasoning did not quell the terror that with one tiny slip he would lose himself to the darkness and silence, merge with it. This is crazy, he told himself, but the fear stayed. The motion, the dancing of the molecules of color, could not be willed away with what he thought or didn't think, though he believed that any false, sharp thought might set in motion a chain reaction that would end, not in death, but in the dispersal of Jack Hawn.

After a while a picture came to him—black and white—from a movie in grade school, a picture of ping pong balls in a chain reaction in some glass chamber, and then the picture of himself flying apart like that made him laugh, a short, sharp snort that made him have to wipe his nose and startled the cat asleep on his feet. When Jack noticed the warmth and heft of the big cat, he automatically swept it off the bed with his leg but immediately regretted it. Why did he do that? That's the same, he thought, as automatically smashing the bugs he found around the house. Janet always made a big deal about gathering them up in paper towels and shaking them outside the door, even in winter. It irritated him—her prissy concern for spiders. She would release them outside to a slow death by freezing; in here they could get a nice quick squash and that's that. He'd even heard her talking once to some damn bug: "Get behind the counter before Jack sees you." How different they must be, he thought, if she had to talk to bugs in the house, and he had to kill them. But cats shouldn't be on the bed. They just shouldn't. It's unsanitary.

He was cold and pulled the blanket up around his shoulders. It was the goddamned air conditioner still going full blast. "Relieved. That's what I am." He said that out loud. Then the fear was gone, only dimly remembered. He told himself again that she called from down in Illinois in the middle of the night to ask him to go home, to say she's not coming back. But he couldn't go home, and he didn't know why, and right now he didn't want to know why, but he did know that now he wouldn't have to keep his face together in front of her and see hers always in front of him.

Jack got up and, shivering in his shorts, went into the living room, pried out the stick that jammed the patio door closed, and opened the door to the night air. He stepped out on the little balcony of their condominium and found that it was cool enough now to shut off the air conditioner and open the windows. Jack turned to go in, but, with his hand on the door, turned back to see what there was to see in the middle of the night.

The greenish lights lit the grass already scorched in June. There was no motion anywhere except moths and June bugs around the lights. No cars, no people, no cats or raccoons. Just the sound of other people's air conditioners and, in the distance, the interstate. Jack stood a moment, feeling foolish about his earlier fear, thought of the empty rooms behind him, and decided again that relief was what he felt. Then he heard a train, not just the whistle, but the engines and the freight cars passing over the rails, and again he was amazed that the train could sound so close in the night, when he knew the tracks to be almost a mile away. The sound always pleased him, made him close his eyes in contentment. He hurried back into the bedroom, shut off the air conditioner and opened the window wide. The train was even louder. He got into bed quickly so he could begin to sleep with the sound of the train. He was almost asleep when the sound faded away, and there was a moment when he thought he might slide into some fear again. Then Janet's big cat jumped up on the bed and curled at his back where Janet used to.

As he slipped into sleep, he saw, as if from the ceiling, Jack and Janet Hawn, husband and wife in bed. He saw them sleeping back to back, touching only at the bases of their spines, holding an empty space between them, a vase shape, a wedge of darkness. They were joined at the hips like twins born out of the same belly, not connected at the head or the heart, but joined by the accident of the place of their birth, their growing up together, their being neighbors.

Two

A rattling sound woke Jack up the next morning. It was the goddamned cat prying at the kitchen cupboard where Janet kept the cat food. "Cut it out!" Jack yelled, and the rattling quit.

He woke with an anger he figured he hadn't felt since the winter he and Janet were married. The anger rose like lava into his throat and made him feel heavy and breathless. He and Janet were married in October, so it must have been that next February that he had realized there either was or had been something between Janet and Carl. His own brother, his married brother.

Carl and Shirley and the kids had come over for supper. Ed was there, too, and Jack always wondered if Ed saw the same thing he did. He remembered the bitter cold that evening, the sunset coloring the snow, yet leaving most of the sky heavy and iron hard. He remembered the commotion of Carl and Shirley and the three kids coming into the kitchen with all that cold air, the confusion of the kids and coats and boots. And he remembered noticing a tiny stillness in the middle of all that, a little eddy in a fast current, between Janet and Carl, in the way they wouldn't look at each other or touch each other even casually; it was in Carl's wary face and in Janet's attention to the children, though her body was aware of where Carl was. Jack's pain was instantaneous; he knew he was right. He grabbed up Carl's little boy, began swinging him back and forth in the air in front of him—the boy screaming in delight and fear, "Windshield wiper! See, Dad, I'm a windshield wiper!"—back and forth, back and forth, to block out the sight of the two of them, to keep back the waves of knowing. Back and forth and back and forth, until finally the boy grew pale and clawed at Jack's hands and kicked. Jack let him down amid the silence in the room. Ed took him aside, asked him what they were going to do about the crack in the window over the stove.

He and Janet had made love that night, and afterwards he somehow let her know he knew. But that made it worse. Then he wanted to leave her, at least for a while, to walk out of the place where this pain dwelled, but that night there was a blizzard, and for three days they were snowed in. Jack wondered if he and Janet would still be married if it hadn't snowed that night. She had tried to explain the next morning, but he hadn't let her. He was afraid he would hear things that would make him feel even worse. He was afraid he would hear what the silence between Janet and Carl enclosed. He was afraid it was something still alive. Yet this feeling now was not as bad as it had been all those years ago.

Again the cat rattled the cupboard door. It was late, almost 9:30. Jack got up and went into the kitchen. He shoved the cat aside with his foot, got out the cat food, fed the cat, and started coffee. He knew he would feel better when the day was underway, when he was busy. This business with Janet wouldn't be so bad if he were going to work this morning, if he got that job in Sturgeon selling forklifts to the army.

After he had more copies of his resume made and put in his appearance at the unemployment office, Jack went to the Hardee's Drive-Thru and ordered two cinnamon raisin biscuits, a large coffee, and a large milk.

The voice came over the speaker: "We're not servin' breakfast no more!"

"'We're not serving breakfast *any* more!'" he said back. They all must have heard him because there was a lot of amplified laughter. He ordered a sandwich instead of the biscuits, and when he paid at the window, several people were peering out to get a look at the wise guy. A sign in the window said Hardee's was hiring. Would it come to that, working at Hardee's with retirees and high school kids?

They used to go out for breakfast every morning, Jack and Janet, Hardee's or some diner. Janet would meet him when she got off work at 7:00 after taking care of some sick old person all night, before he would begin his day reading the want ads, writing letters, calling around. They'd sit in a booth, and she'd be tired after her night's work. She'd want to talk, but she'd want to talk about them, she said, about the two of them, their problems, their plans—what they were going to do. But Jack couldn't talk like that. He tried to explain to her once or twice that he couldn't talk about a thing until he got a job, that his getting a job had to come first. Then there might be some things to talk about, personal things, but in the meantime, he couldn't talk about that stuff. He tried to tell her it felt like he was about half choked all the time. But she never got it. So they'd sit here, and the waitress would bring them coffee and take their order and go off to the kitchen, leaving Jack alone with this woman who was about to ask him a question that he couldn't answer or ask him a question that was really another question that he couldn't answer. Like she'd ask him, "How are Dave and Linda getting along?" Jack knew that it wasn't Dave and Linda she was asking about. It was Jack and Janet; how were *they* getting along? But she already knew the answer to that question: Lousy. So the real question was, Why Lousy? And the real question under that was, What are you going to do about it, meaning, How was he—Jack—going to change?

Janet never realized that he was a professional talker. He'd been a farmer and a graduate student, a manager of all kinds of stuff, a working stiff, a salesman, and an interviewee, and all those jobs took skill in keeping up a line of patter and steering talk in the direction you wanted it to go. The poor girl never had a chance against him. And he felt bad about it. He saw her face in his mind, and he felt bad about it. She still was pretty to him, but her face seemed tighter and smaller every year. The skin around her eyes looked fragile and papery. It was partly his fault; she would be prettier if she didn't have to worry about him getting a job and about him being a shit while he didn't have one.

Jack could see himself in a diner booth with Janet. He could see himself start up the talk; he would seem to begin to answer her question, then one thing would always lead to something else. He might start in about some bastards who interviewed Dave and didn't hire him, and that would lead to bastards who interviewed him and didn't hire him. And from there it was on to bastards who'd fired him and bastards who'd fired Dave. Then he might have a whack at the pricks who were running the country. The goddamned governor. Congress, of course. The oil companies. The bail outs. Then back to the bank they'd just pulled all their money out of because of their stupid accounting. The condominium management. You name it—there was no shortage of shit.

Jack would watch Janet's face as he talked. At first she followed him, waiting for an opening, hopeful, alert, purposeful, pathetic. Then as his wall of words got thicker and thicker, she'd begin to be both angry and bored. Her face would begin to harden. She wouldn't even look at him; she'd look at people at another table. She wouldn't be listening or even pretending to listen. Now and then she would look toward him, but not at his eyes. She would look at his mouth; she would watch it talk, as if it were a disgusting rodent or something. Then he would begin to picture it himself—his mouth opening and closing, the dark hole of it, the lips wiggling around the words. He knew then that they both saw Jack Hawn as ridiculous—ridiculous and pathetic. Her face was grim and tight. And without moving her mouth, without a word, she was saying to him, You are a shit, Jack. It was as clear as if she had spoken right out loud. And she was right. But he couldn't help it. He *had* to not talk about what she wanted to talk about, and he had to say what he had to say. It always ended with Janet grabbing the check, leaving too big a tip. She would be out the door while Jack was still finishing his coffee.

Maybe she was right to go back to Half Moon; maybe she was right about them, too. Maybe if they were to be together, it had to be there. She was out of context here, too. And the questions were the same for her—where and how do you live your life.

He wanted to drive, but not south to Illinois. Too many complications, too many connections. He might go to Half Moon if just Janet were there, or just Carl, or just Janet's dad. But the three of them created an invisible force field that kept him away. Besides, the air there was thick with all the past and everyone's disappointment in him. Each time he looked at a face there, he saw that they saw what he could have been, standing right next to what he was. He wanted to go someplace where only strangers breathed the air—though he would have to take the damned cat. Somewhere the air would be thin and clear, not thick and humid like in Illinois and better than the air in Green Bay, which stank of the paper mills and the perfumed dryer sheets they made not far away.

After he left Hardee's he took his lunch down to Bay Beach Park. Jack thought of the time he and Janet had driven years ago to California to see the Pacific Ocean. From where he had stood on the sand at the edge of the continent, Jack had watched the sun go down into the water and waited to feel something. But all he felt was too heavy, too pale, dressed wrong. He was a Middle Westerner out of his element.

He parked the car and walked down to the shore of Green Bay, trying to count the times he'd gone to a beach since they'd lived in Wisconsin, within a mile or two of Lake Michigan or Green Bay. It wasn't very often. After the first few times, Jack avoided the beach, using reasons like, the sun is bad for you, or the sand makes you itchy, or there's nothing to do down there anyway. But none of those was the real reason: The beach made him feel awful. The beach in the summer had everything you could want to make you at least temporarily happy—blue sky and white clouds, beautiful sparkling water, warm sand, and breezes—but it wasn't for him. It made his ache worse and his bad luck more apparent. What business does an old farmer have at the beach? Though the beach didn't cost anything, everything near the water sounded to him like money: the close little breezes blowing rivulets of sand counted paper money, the waves fumbled among coins, and the delicate change of hardware on sailboats was the coin of a prosperous realm. He never had the right clothes or a tan, and there was nothing he could take home from the beach but the small change of sand in his pockets.

His steps were awkward on the dry sand beside the bay. His jeans were too tight and hot. The walking worked his belly muscles and the muscles in his calves and thighs. Jack sat on the sand beside some driftwood and ate his sandwich.

There were only a few other people at the beach. A couple walked along the sand, and a boy stood at the end of a rubble breakwater fishing in the little waves.

When he finished eating, Jack got up and threw out the trash and then, at the edge of the water, he stepped up on a block of the boulder-sized rubble, balancing awkwardly with his hands in his pockets. The water under the concrete slabs made a hollow ringing he didn't know a word for. He turned to the boy fishing and asked him what he was fishing for.

"Perch," the boy said. He wouldn't look at Jack. He'd been warned about talking to strangers. But what the hell.

"Any luck?"

"Not yet." The boy's eyes darted around like fish, Jack thought, like scared fish in a bowl.

Jack wanted to stick around in case the boy caught a perch so he could see what a perch looked like, but this kid was too spooky. Jack walked back up the beach.

Jack's father wouldn't fish with him and Carl. When asked, D. E. would say, "Where the hell would we fish except at some 'bar' pit where you pay two dollars to fish all day with niggers?" When they wanted to fish, they would go over to Janet's dad's and, though he might be rigging the combine for beans, right then Ed would take Jack and Carl and sometimes Janet over to the state park, where they fished with the dusty bamboo poles Ed hauled down from the top of his garage. The fish they saw were not much bigger than the wriggling grasshoppers they put on the hooks, so they didn't catch anything, but Jack and Carl didn't care. They got to sit on the bank, staring down into water as clear and brown as tea while long-haired weeds moved in slow circles. And they got to hear Ed's fishing stories. They thought they'd heard all of Ed's stories, but if you got Ed in a new situation, it called up a new batch of stories. The only one Jack remembered was about one of Ed's uncles. He was "a drunk," Ed had said, "an alcoholic, as we say now," but he wanted to quit drinking. He lived at that time with his wife and children outside of Shreveport, Louisiana and had a good job working for the gas company. To stop drinking he went fishing after work every day for a year. He got in a little boat all by himself and rowed out to the middle of Caddo Lake, where he fished until it was dark and too late to buy liquor. He caught a lot of fish, and he did quit drinking. At least that's what Ed said.

Since then, in the back of his mind Jack had held that spending time out on a lake in a boat was a cure for lots of ills. Maybe for Carl's drinking. It seemed a sane cure that would give you plenty of time to straighten yourself out and let others know you were serious. Jack wondered if it could work on his bad luck.

Though Jack did not really believe in luck, he believed that you could get stuck on a track that led only toward bad ends. It wasn't bad luck, he would say, but a kind of stink you took on when things started to go against you. At first you would be the only one to notice it, but after a while, some expression around your nostrils or under your eyes or some posture you thought disguised your fear made others look to see what you were hiding. Then they began to notice it, too, and they ran like crazy in the other direction. He knew that being unemployed for three years had made him stink.

The sun was warm, but the breeze cooled him off. Jack sat down on the sand. It would be nice to go fishing with Ed. Or Carl, the old Carl. One or the other. Not both. Their presence wouldn't ask as many questions as Janet's and everyone else's did. Even Janet's goddamned cat seemed to ask questions he couldn't answer.

In the last few months, Jack had caught people looking at him funny, asking something. Or else he was ignored by the ones who used to notice him—most women and confident men—and now he was noticed by a kind of person that had been invisible to him before.

People like the woman in that Greek diner in a strip mall—an old woman, so old or so sick her skin was like ivory and tight on her bones. She was walking out of the place supported between two big female relatives in sweatsuits. As they slowly left the diner, Jack had a long time to meet her gaze—a bald and startling stare, pure curiosity with no civilization in it, like a baby's stare. There could be no doubt that she found Jack's face interesting, and this was interesting to Jack.

The strangest was the man filling the gumball machine in that same diner later that week. The cafe was packed with the lunch crowd—men and a few women from nearby offices, factories, and construction sites. None of the customers spoke to him, but there was nothing wrong in that. It was a busy place, and he was a stranger. He'd do the same. Look up, classify the guy—salesman from out of town—then go back to eating the meatloaf.

The man came in carrying a steel box. He set the box down beside the

Lions Club gumball machine at the door. On the gumball machine he unscrewed something quickly, then dumped all the coins into a metal jar and put them into his steel box. Then he took out a rag and, squatting next to the gumball machine—the man was big, as heavy as Jack was—he wiped the gumball machine with the rag. Without looking at what he was doing, he wiped the stand, the post, the base, and then the clear globe. Then he started over and wiped it all again with the dirty rag, and he didn't look at what he did; he looked around. He watched from down under, invisible to everyone else; he looked around at the people in the diner. Here was a man looking in from the outside. He squatted beside the gumball machine, polishing and polishing. He met Jack's eye, no one else's. He didn't smile or acknowledge Jack's seeing him. His eyes and his smile could have been warm but didn't go that far; he only looked. Through all the tables and talk and crisscrossing of waitresses and clatter, he looked at Jack, and Jack looked at him. Where are we, Jack wondered. Where am I going?

The sun had come around, and Jack's jeans stuck to his legs. He remembered he was wearing those red briefs Janet gave him; maybe they looked like swimming trunks. Jack slipped off his jeans and walked down to the green water. The mothers looked up but looked back to their children. Slowly Jack waded into the water. Though he shrank from the cold water at first, his arms and legs and then his torso gave in to it. His weight was lightened. He swam to feel his borders blurring among the molecules of water. He swam a long way out, thinking of the life that moved in the dark water below him, and then he swam back looking at the land from behind the ragged tops of waves.

When he trudged back up onto the sand, everywhere he looked he saw water, just water. Clouds were water. The sky behind the clouds was the color of water. Water was between each grain of sand at the hard edge of the beach. The tracks of water were everywhere—in the miniature deltas in the sand, on the satiny wood washed up, on the smooth stones and the cracked ones. The light flashing off the surface of the bay might as well be splashes, it was so watery. The leaves of the locust trees growing over the bank were filled with water, and so were the trunks of the trees and every blade of grass and every stalk of weed. And the gulls and the fish. The live fish. Only the dead fish dried in the sand were not water. Nothing alive wasn't water. Everywhere he looked he saw the watery newness of the world, its sparkling, prickling moments held earth-to-earth with a fragile force.

He was water. Ninety-some percent water. As he made his way over the sand, Jack stopped and looked up. He turned all around. He was alone on the beach. "Water!" he said to the sky. "What would it matter if this 190 pound sack of water didn't have a wife?"

Thomas Bontly

December's Dreams

Joe Kelsey stood in the shelter of the little row of attached houses and watched the rain slanting across a similar row of gray stone houses across the street. Their doors and windows had all been shuttered, giving them the forlorn look of structures abandoned forever by their owners. A cold wind blew along the street, and Kelsey, bereft of his London Fog, had only a sweater and light jacket to ward off the elements. But it wasn't much warmer indoors, and he was enjoying one of the mild Cuban cigars he'd picked up in Carcasonne.

Inside the house his wife was fixing supper, experimenting with French herbs and spices, learning her way around the primitive kitchen with its cheap crockery and mysterious utensils. Neither of them had been able to work the awkward little contraption the French called a can opener. Actually, they didn't know what the French called it, because neither of them could speak more than a few words of French, in accents which brought sneers to the faces of the waiters, shopkeepers and officials with whom they dealt. Kelsey had finally hacked his way through the can of tomato sauce with a jack-knife and pliers but suggested that they'd better avoid canned goods from then on. Of course that meant daily trips to the market, thirty kilometers off in Carcassone, but at least such excursions gave them something to do.

The December dusk was settling in early, obscuring the muddy fields and wooded hillsides that lay beyond the village, but the narrow cobblestone lane was illuminated by tall vapor lights at either end of the block. Almost as if people still lived here, Kelsey thought. Perhaps they did live here at other times of the year, when the village served as a bucolic retreat for French city-dwellers, but in this bleak season, only three of the thirty or so houses surrounding the hilltop chateau were occupied. The chateau was dark, its windows shuttered, its gate chained, its gardens untended. Beyond it lay the cemetery—its weathered crypts and tipsy monuments overhung by weeping willows, overrun by moss and ivy. Kelsey rather liked the cemetery, since there at least it was possible to imagine a spirited assembly on moon-bright winter nights, a ghastly frolic that might have passed for a social occasion.

Carolyn tapped on the kitchen window to let him know that supper was ready. Kelsey flicked his cigar into the street and went inside. He wiped his feet and hung his jacket by the stairs. Then he went to the kitchen and took a bottle of wine from the refrigerator. "Seems a bit warmer in here now," he said as he set about sinking the corkscrew.

"That's just because you've been outside," Carolyn said. "Or maybe the stove is producing a little heat. The circuits broke again, so I had to turn off the heat in the living room."

"Damn. I don't think this house was meant to be inhabited at this time of year. The agency should have warned us."

"If you remember," Carolyn said, "our first several choices weren't available after late November. That should have told us something about the climate, don't you think?"

"Yes, another screw-up," Kelsey said. "I can't seem to do anything right, can I?"

They had needed a place to spend a few weeks between the Italian segment of their year and the English segment. The south of France had sounded inviting, and Kelsey imagined balmy days on scenic beaches, a nude sunbather or two just to liven things up. That was before he knew about the *mistral*, that cold north wind from the Baltic Sea that swept across France and made it much too cold for sunbathing in December, with or without clothes.

They sat at the kitchen table, and Carolyn lifted the cover of the frying pan to reveal her lamb stew.

"Hmmm, smells good!" Kelsey said. "You're doing wonders in this miserable excuse for a kitchen."

"It's something to do, anyway," Carolyn said as she dished up the stew.

"If only it would stop raining, we could get out and see something of the country," Kelsey said.

"Where would we go? There don't seem to be any footpaths from the village, and every field or woodlot I've seen has been fenced. Besides, there's that pack of half-wild dogs to contend with."

"Well, maybe we could drive someplace—south toward the Pyrenees. We might find some places to hike in the mountains."

Carolyn looked unhappy, and he remembered that she had recently developed a fear of heights. It was that detour through Switzerland, he thought; he never should have taken some of those back roads.

"We wouldn't have to go all the way up," he said. "Just far enough to find a park or something—a hiking trail that isn't patrolled by German shepherds."

"If you want to," she said and began to carve the long loaf of crusty bread.

He took a sip of wine and felt bits of cork on his tongue. Why was she always so damn submissive? If she didn't want to go to the goddamn mountains, she should tell him so.

"I'm just thinking of you," he said. "You want to see some birds, don't you?"

She put down her fork and brought her napkin to her eyes, which, Kelsey saw, were brimming with tears. "Joe, I don't think I want to see any birds, ever again! Not after what happened to us in the Camargue!"

"Oh, come on," he said, reaching for her hand. "It wasn't your fault."

"I was the one who wanted to go there."

"You suggested it, but I agreed. I was all for it. And anyway, I was the one who ignored the sign."

It had been a very small sign, hardly noticeable from the parking space they'd chosen: *Do not leave valuables in your car.*

Kelsey heeded such warnings when it was convenient, ignored them when it wasn't. Besides, he thought they were just going inside the Nature Center to look at the exhibits. But Carolyn found a naturalist who spoke English and suggested a nature trail that led past several ponds—only seven-tenths of a kilometer. Kelsey never considered staying with the car. He had forgotten about the sign. And after all, they had survived Rome, the city of pickpockets, and Naples, the mecca of muggers. Who would expect trouble way out in the middle of nowhere?

Later, they heard about the bands of gypsies who roamed the highways of southern France and used the Camargue as their sanctuary, but at the time he worried only because the walk was taking longer than they expected. He did try to hurry Carolyn along a bit, but after all, it was her first day of birding since they'd left Switzerland, and she had been very good about the things he wanted to see. Kelsey did his best to take an interest in the three or four mundane tits and larks they flushed from the wintery underbrush.

Even when they came back up the road and saw the small red van with its three swarthy, unshaven occupants barreling out of the lot—even then Kelsey wasn't unduly concerned. But when he saw the Citroen's door ajar and found its lock sprung, and when he looked into the formerly cluttered back seat and saw an emptiness that sprang at him like a spiteful rebuke, he realized that he should have heeded the warning on the sign.

As Kelsey swung the car around, Carolyn quickly checked beneath the seat and found her purse; their travelers checks and passports were safe, at least. She clambered into the backseat and pulled up the cardboard shield which hid the contents of the trunk. Their two big suitcases were also still there. Nevertheless, Kelsey roared out of the parking lot and set off down the narrow gravel road across the marshland in pursuit of the red van. He had never been robbed before and was full of outrage, convinced that he could run the red van into the ditch and throttle its occupants.

Carolyn tried to reason with him: "Please, Joe—don't drive so fast! What will you do if we catch up with them?"

"I'll think of something," he said, but it was beginning to dawn on him that he couldn't risk their lives in such a foolhardy endeavor. He pictured the two of them in a muddy ditch, their throats cut, their eyes staring sightlessly at the sky, and knew sadly that he couldn't afford to challenge the trio of swarthy vagabonds.

They decided to drive into Arles and seek the assistance of the police. The gendarmes would come to their rescue. They would form a posse, ride out on the Camargue, track the culprits down. Or they would put out an all-points bulletin for the red van, set up roadblocks, round up a set of likely villains for Kelsey to identify.

But when they reached the city, they found that the gendarmery was closed for the lunch hour. A young officer informed them politely but firmly that their crime could not be reported until two p.m. then shut the heavy door in their faces.

Kelsey found it hard to believe that the authorities could treat their loss in such a cavalier manner. Not just his raincoat and his brand new carry-on, but his camera, all his exposed film, his notes toward a new book on the Romantics in Italy, and good God, their tickets! Their train tickets back to Frankfurt, even their plane tickets home to Minneapolis, had been in his bag. Carolyn meanwhile was beginning to make her own inventory of losses: her make-up, her hair brush, her prescriptions and his, their vitamins and aspirins, toothbrush and toothpaste, address books, and oh—their Italian souvenirs! The little gifts she'd picked out for their friends in Germany. "Oh Joe," she wailed, "it's all my fault. We never should have come here. I hate this place!"

Kelsey continued to hold and pat his wife's hand. "Hey, honey, for the hundredth time, it wasn't your fault. I wanted you to see something besides pigeons and starlings, remember? We agreed it was time to do something different. And anyway, we're not going to let this spoil our whole trip, are we?"

Carolyn wiped away her last tear and gave him a smile. "You've been wonderful, Joe. You really have. The way you dealt with the police and the insurance people and made all those phone calls—I couldn't have done all that."

"Oh, sure you could have," Kelsey said, though in fact he had been rather impressed with his behavior. What Hemingway would have called "grace under pressure." He did what he had to do, fought his way through the French bureaucracy, looked after details, made the decisions Carolyn was in no shape to make. And most of all, he resisted the temptation to blame their misfortune on her or her birdwatching.

Kelsey had never understood his wife's passion for birding but no longer made light of it. Carolyn needed fresh air and open skies the way some people needed a career, a religious experience, or an extramarital affair. It was her hedge against time, against the loss of youth and the departure of her children. Kelsey wondered what he had ever found that could serve him as well as her birds had served her.

After supper they cleared the table and got out the cribbage board. Carolyn was already three games ahead and nearly gained two more on a skunk, but Kelsey came back strong, making it onto fourth street before she pegged out. They polished off the wine as they did dishes. By now it was just after seven, and Carolyn said she wanted to write some letters. Kelsey had written to several people that morning, and he was still too discouraged to try reconstructing his notes. Renaissance painting and romantic poetry, what a shopworn topic; if he never wrote the damn book, who would care?

He turned on the little black and white TV in the living room and checked each of its three channels. Though they were all afflicted by some form of interference, he managed to watch part of an old movie—aristocrats in powdered wigs prancing around some eighteenth century ballroom—then turned to a soccer match. Barcelona versus Lyon. Somehow he didn't greatly care about the outcome.

Shortly after eight, the doorbell rang.

Remembering the empty chateau and its spooky graveyard, Kelsey looked through the peephole before unlocking the front door. A large young man with wet black hair stood waiting on their doorstep. Kelsey recognized Jean Michel, the son of the only family still resident on their street. He quickly unlocked and opened the door.

"Hi, there. Come on in."

"Bonsoir, Monsieur," Jean Michel said with great dignity as he crossed the threshold. "I have come to speak English with you."

On the day of their arrival, Jean Michel had introduced himself and offered his services as a translator while they were staying in the village. He had also shyly indicated that he wouldn't mind a chance to practice his conversational English. He seemed like a nice boy—quiet, soft-spoken, serenely confident in his opinions—a bit like the Kelseys' own son, come to think of it. They had encouraged him to drop by whenever he could.

Kelsey took Jean Michel back to the living room. "Look who's here, honey," he announced. "We're going to have a little chat. Sorry it's so cold in here, Jean Michel. We can't run more than one of these little heaters or we break the circuits. Could I get you anything—a Coke, maybe, or a glass of wine?"

Jean Michel smiled at the offer of wine. "No, no, a Coca Cola would be fine, please."

Somewhere Kelsey had heard that children were allowed to drink wine in Europe but perhaps only at the family dinner table. He went into the kitchen, got Jean Michel a Coke, and poured himself a stiff slug of cognac.

"So then," he said, sitting down across from the boy, "tell us about yourself. Do you go to high school?"

"Yes, I attend the school in Castelnaudary," he said. "It is my last year. Then I will go to the university."

"Ah, and what will you study?"

Jean Michel looked as if he had been asked this question too many times before. "I am thinking between engineering and mathematics," he said. And then, smiling, as if he had hit upon a more interesting topic: "Have you had yet the opportunity to visit some of our many local attractions?"

"We spent a day in Carcassone," Kelsey said, "but the weather's been so bad, we haven't been going out much. And we lost all our maps and guidebooks in the robbery."

Jean Michel had heard about the robbery. *"Voila!"* he said, producing a selection of maps and brochures from an inside pocket. "My parents anticipated this need. Perhaps you would like me to suggest some interesting itineraries?"

For the next hour Kelsey followed Jean Michel's finger around southern France and listened politely to his account of what each region had to offer the tourist. He particularly recommended the old fortress at Foix— "a most beautiful edifice," as he put it—and the drive from Foix to Quillan, through the foothills of the Pyrnees.

"But won't those mountain roads be icy this time of year?" Carolyn asked.

"I do not suppose it," Jean Michel said. "The weather is expected to improve by tomorrow, and the scenery along that route is quite beautiful."

"Well, honey," Kelsey said after Jean Michel had gone home, "maybe we ought to try it if the weather's halfway decent tomorrow. We really can't sit here and feel sorry for ourselves all week, now can we?"

"No," she said. "I suppose we can go somewhere else and feel sorry for ourselves." Carolyn did occasionally surprise him with her gift for irony.

Before they went up to bed, Kelsey turned off the downstairs heaters, made sure the doors were locked, and closed and bolted all the shutters. Their bedroom was bitterly cold. They turned the heater up as far as it would go and piled blankets and comforters on the old brass bed. The bed sagged in the middle so badly that they found themselves thrown against one another, like two people trying to share a hammock.

"I suppose we might as well make the best of the situation," Kelsey said, slipping his hand beneath his wife's sweatshirt.

"Joe! not yet! Your hand is freezing!"

"Oops, sorry."

They lay in the darkness, waiting for their hands to warm up. "Do you suppose we're feeling too sorry for ourselves these days?" Kelsey asked.

"Well, you are," Carolyn said.

"Thanks."

"I'm sorry, Joe, but you do keep second-guessing yourself. You've rewritten our itinerary a hundred times, and you're always complaining that we're not getting our money's worth, or that somebody's trying to rip us off. Even before the robbery you were getting a bit tiresome; now you're impossible."

"I try to learn from my mistakes."

"That's admirable," Carolyn said, "but at this point there's really no way we can change our plans, and no way we can alter what's already happened, so why keep torturing yourself?"

"There's always next time."

"Next time," Carolyn said with a little laugh, and Kelsey got the impression that the next time he suggested they spend a sabbatical year in Europe, she might have a few revisions of her own to propose—such as that he leave her at home.

They were quiet for awhile, and Kelsey reflected on that aspect of his character that could never rest satisfied with what life had given him. Last winter, when his chronic disatisfaction with his career and accomplishments had led to a prolonged period of insomnia, he asked himself one sleepless December night just what *would* make him happy. He came upon this vision of Carolyn and himself, as free and footloose as a pair of college students, ad-libbing their way around Europe, staying in old country inns and rented cottages, going wherever their fancy took them, seeing whatever there was to see. How soothing, and how motivational, that vision had become. And yet, when he had finally, after much planning and budgeting, made his dream a reality, during their first four months abroad he had found a whole new field of things to complain about. He deduced that dissatisfaction itself fueled the engines of his soul.

He was about to express some of these thoughts to Carolyn when he heard her breathing deeply and knew she was already asleep. He rolled over and, hooking an arm over the edge of the mattress to keep from falling back against Carolyn, set his mind on sleep.

Sometime during the night Kelsey dreamt that he was attending a costume ball in the chateau on the hill. He found himself dancing in a large and elegant ballroom with a strange woman. Some quirk of light in the mirrored room, the shifting shadows of the dancers all around them, prevented him from seeing the woman's face, but he knew she was attractive and charming and that dancing with her was a privilege. Perhaps she was a former mistress of the chateau, risen from the cemetery to host this gala ball, or perhaps she was an old flame from Kelsey's youth, come all the way to France to haunt him.

In any case, he knew even as he held her in his arms that she was a phantom who drew her power from the wickedness in his own heart. He thought guiltily of his wife, still asleep in their cold bedroom, then spotted Carolyn standing alone at the edge of the marble dance floor. She made no protest, voiced no rebuke. She just watched sadly, forlornly, as he waltzed his spectral partner around the room. Kelsey tried to concentrate on the dance, to enjoy his evil freedom, but increasingly his heart rebelled. Wherever he turned his head, he now saw Carolyn watching him with her sorrowful dark eyes. Filled with pity and remorse, he broke off the dance, took Carolyn by the hand, and led her resolutely from the chateau.

Kelsey woke from his dream and lay in the cold darkness, listening for suspicious noises. The old house creaked beneath the wind; its timbers snapped from the cold; but Kelsey felt confident that no demons had followed him home from the chateau. And he knew now why he had done the right thing in bringing his wife to Europe.

The next morning the heavy layer of cloud that had covered the village for three days began to tear apart. There were intermittent squalls but also glimpses of sunshine and blue sky. Kelsey and his wife ate breakfast, then packed a lunch and loaded the car with maps, guidebooks, birdbooks and binoculars. They drove south toward Foix, and the country roads were dry and lightly traveled. Bits of blue sky continued to appear overhead, and in the fields, large pools of rainwater reflected the restless movement of the clouds.

"So what birds are we looking for today?" Kelsey asked his wife, for despite her disclaimer of yesterday evening, she was alternately scanning the fields with her binoculars and paging through her *Birds of Europe*.

"Hard telling this time of year," she said. "We might see some larks or sparrows, maybe a thrush or two. There's a buzzard right now, soaring just beyond those trees."

"What's the best thing we could see?" Kelsey was inclined to go for big game, birdwise—the rare, exotic birds most birders waited lifetimes to see.

"Well, a golden eagle would be nice, or a black kite. The best thing we could see is a vulture called the *lammergeier.* It's extremely rare, found now only in the Pyrenees." She showed him a picture from her book.

"Hmm, he's a handsome fellow, isn't he? Too bad we won't be going high enough to find him."

Carolyn declined to comment.

They reached Foix late in the morning. Snow flurries alternated with bright sunshine, but the roads were dry. They explored the city, found a place to park, and climbed the hill to the castle. Though not quite such a "beautiful edifice" as Jean Michel had promised, it was a moderately impressive hunk of military architecture. Perhaps because of the low clouds, the mountains were not visible from the windy parapets. Only a few ravens and magpies inhabited the castle grounds.

"The weather looks pretty good," Kelsey said as they returned to the car. "Should we try that route Jean Michel showed us, through the foothills to Quillan? We may find a few places to get out and walk."

"If you want to," Carolyn said—an answer Kelsey seldom found satisfactory, though in this case he decided not to query further. They ate lunch in a little park beside the river and set out.

For the first five kilometers the road followed the river valley, then veered to the east and climbed through a pine forest. A light mist began to fall, and Kelsey turned on the windshield wipers. "Is it starting to get slippery?" Carolyn asked.

"No, I don't think so. You just keep your eyes peeled for that lammerskite, or whatever it is. I'll handle the driving."

Though Carolyn never criticized his driving, she had begun to send signals that in her opinion he sometimes drove too fast, or inattentively. He knew she was especially nervous with the more aggressive pace of European traffic, but Kelsey considered himself a good driver and resented hints to the contrary—especially since she now relied on him to do all the driving.

They were crossing a high plateau, from which they could probably have seen the snowy peaks of the Pyrenees if not for the heavy clouds to the south. Ever since his first view of the Alps as a young man, Kelsey had loved the mountains and found nothing more inspiring than a range of snow-covered peaks. He hoped they would get at least a glimpse of the Pyrenees before they veered off for home.

The road began to ascend in a series of switchbacks with steep grades. The snow showers intensified, and Kelsey began to notice traces of white along the roadside. He thought of turning back but knew they should be starting down toward Quillan soon. This route, Jean Michel had assured them, did not take them very far into the mountains. Still, he was surprised at the persistence of their ascent and at the mountainous aspect of the scenery.

At a turn in the road Kelsey touched the brakes, and the car began to skid. It was quickly and easily corrected, but Carolyn felt it and released a gasp. "Joe, are you *sure* it's not slippery?"

It was the gasp, more than the question, that annoyed Kelsey. "Would you for Christ's sake please give me a fucking break? I'm doing the best I can."

Too late he realized he had put too much bite in his voice, had used too many gratuitous swear words. He wasn't really *that* annoyed, but now

Carolyn thought he was. She retreated behind a wall of silence—her usual way of dealing with his outbursts.

Now I suppose we won't be talking to each other for the next few days, Kelsey thought grimly. As if they weren't isolated enough in that miserable little village, in this cold and loveless country. He knew a quick apology might spare them both the agonies of a protracted quarrel, but at the moment he really needed to concentrate on his driving. The roadway had turned gray in places with a film of icy slush; the snow was accumulating along the shoulder and clinging to the windshield above the arc of the wipers.

Kelsey cut his speed way down and sat upright, both hands gripping the wheel, his gaze fixed on the road ahead. They were working their way toward the top of a pass, and the terrain was barren and rocky. The wind swept in gusts along the ridge. They passed a sign—"P 100 m."—indicating a turn-out in one hundred meters. Kelsey thought it might be wise to pull off the road and let this storm abate. Unless, of course, conditions got worse. He was still debating when they crested the ridge and came in view of a remarkable phenomenon. Though they were still in the midst of a snow squall, the skies to the south had cleared, and there, in a vision too abrupt and breathtakingly beautiful to seem real, Kelsey saw the snowy peaks he had been longing for.

Brilliant white against a deep blue sky, the Pyrenees stood above the storm like a serene and elegant dream. But far from pleasing Kelsey, these majestic peaks only seemed to mock him with their distance, their unattainability. Of course the mountains were there, and others had seen them, had climbed them, had stood on their summits. But the Kelseys would always confine themselves to the foothills and then risk their necks, quarrel in the process, because that was the way they did things.

"Joe, watch out!"

Too late, Kelsey saw the sharp turn to the left. He stabbed the brakes, and the car went into a skid. Thirty midwestern winters had taught him to let up on the brake and work the gas pedal instead. He cramped the wheel hard to the left as the guard rail loomed up before them, then dropped away. He had no idea where the car was going. He couldn't hit the brakes for fear of another skid, yet he couldn't go on sliding sideways down the middle of a mountain road. Then he saw the entrance to the turnout to his left and gunned the car onto its rough-graded surface. They bumped and pitched and rolled to a stop.

"I think I'm going to be sick." Carolyn opened the car door and got out. He watched her cross over to the low wall rimming the parking area. Beyond was a steep drop-off, a swirling white void. The wind tore at Carolyn's hair and billowed her jacket. She leaned over the wall, as if to retch, and Kelsey thought he should go to her assistance. But his own legs were still shaking, and he wasn't sure Carolyn wanted his help.

He rolled down his window to call to her but found himself unable to speak. He seemed at this moment to have been cheated of all sorts of valuable and important things, and he asked himself if it wasn't his wife's will, acting always as a counterforce to his own, which had kept their lives so appallingly mediocre, so mired in the foothills, when something sublime had beckoned on the horizon.

For some minutes he sat hunkered down behind the wheel, relishing his bitterness, and then, at the ghostly kiss of a snowflake on his cheek, he remembered last night's dream—the mysterious chateau, the faceless woman, the dance of death that had held him until he saw Carolyn watching sadly from the sidelines. He covered his eyes with his hand and tried to understand what the dream was telling him. Perhaps it was simply this: that the only thief he had to fear was the greedy little culprit who lurked in his own dreams, who wanted nothing less than to steal all he possessed and leave him with with nothing.

He looked up, ready at last to go to Carolyn's assistance, but where was she? The parking area before the low wall was as empty as the backseat of their burgled vehicle—and as frightening. He leapt from the car and raced across the slippery gravel, nearly tumbling over the wall himself. Bracing himself on his palms, he saw that a trail led down among the rocks. Kelsey started down this trail and soon came to his wife, just beyond a large boulder.

Carolyn had her binoculars trained on a large dark bird circling above them, then gliding out across the valley. Its vast wingspan held it steady against the wind, and the brightening sky showed the golden-brown tone of its breast and sharply tapered trunk.

"Is it—is it that vulture you wanted to see?"

"No, but it's almost as good," Carolyn said. "It's the golden eagle. Isn't he magnificent?"

Kelsey could tell by her tone that their quarrel was forgotten. A valley of considerable beauty lay spread below them, and the several small villages in its folds seemed to come miraculously alive with color as the sunlight moved across them.

"I told you I'd find you some good birds up here," Kelsey said. He put his arms around his wife, holding her close as she continued to admire the majestic bird. He knew that eventually she would let him look through her glasses; in the meantime, he was happy with his chin on her shoulder and her hair in his face, and he looked forward to another night in the village, when they would find some way, he was sure, to outwit the sagging bed and its many quilts.

Margaret
Benbow

Marrying Jerry

I met Jerry at a time when I was suspecting I didn't have a life. This happens periodically to people who read a lot. I met him at his health food store, a little marvel of color and order. I would drag myself there on the days when I felt parched and weazened, when life had been a bitch. I would waveringly negotiate the step on the threshold, even the hem of my tragic winter coat drooping with multiple deficiencies. The instant I was inside, I was aware of the compact, humming heart of the store. Every worker knew what to do. Fruits were sold only in their season, and faithful customers like me understood why it would be wrong to carry strawberries home over ice and snow. We felt the sun-strength emanating from the little round yolks of the fertilized eggs.

Jerry was scrubbed and sexy, in a working-stiff, Populist kind of way. We became friends over the unfiltered honey vat, when nobody else was in the store. The vat was glass, and he noticed a little brown thing in the bottom, under the gummy honey-sea. He scrubbed his arm like a surgeon, then said, "Don't take pictures, they'd close me down," and plunged his arm up to the pit into the vat. His fingers closed on the brown object at the bottom, and he brought it up, his other hand stripping honey from his arm as it hit the air. He squinted at the twig-like thing. "It's all right," he said. "It's a flower stem." I stared at the bronze animal hairs on his arm, all glazed and matted with gold. My tongue clove to the roof of my mouth, witless with lust. I actually wondered if he would take it amiss if I offered to lick the honey off his arm.

I did no such thing, of course. We became better friends, gradually. He rototilled my garden without being asked, brought flowers unexpectedly, and later on, cooked me big range breakfasts. He was also as good as he could be, attending study groups at the local Unitarian church. This was a special church where you didn't have to believe in God or Jesus but instead learned how to tread lightly on the earth. He studied parenting methods in wolf packs, handed out MEAT IS DEAD stickers at his store, and shared advice about how to treat your partner lovingly and caringly, and without wasteful expenditure.

Jerry used to hand me out of his old pickup like a rich jewel.

One time I said something, very hesitantly, about my plain face. "It doesn't matter," he said, so simply that I knew he meant it. "Besides, you have such a beautiful body!"

So we were married. Jerry wrote the ceremony, in which we loudly and repeatedly stated the immaculateness of our intent toward each other.

Our life continued quietly. I quit my job and began working at Jerry's store. Evenings we would walk home hand in hand, and for supper Jerry would make me magnificent sandwiches. I ate his Denver sandwiches with butter running down my arm. I could hardly chew because of the big smile I had on my face those days.

After about six months, Jerry decided that he believed in God and Jesus after all and joined a new church. The members in this church referred to the Bible as the Big Book, a term I'd associated with the AA manual.

My lack of faith bothered Jerry. On his birthday he asked me, sweetly and tenderly, to read Genesis aloud to him as his gift. So I did. Then he asked me to read him Exodus for Christmas, Leviticus for Valentine's Day, and so forth. I realized that he intended to coax me by baby steps through the entire Bible. I decided many of those Old Testament holy men were as big a collection of bullying, lying, fornicating rogues and felons as I'd always suspected, but I bit my lip. If my love for Jerry was true, I should be willing to read him the Bible word by word to give him pleasure.

Around the time I reached Numbers, Jerry came home from Bible study all excited. A new star was now heading the church, a famous evangelist called Sister Lorna. Sister Lorna had recently published a book, *Let the Angels Call the Shots*. Her theory was that each of us has an angel twin, invisible but with dazzling powers. Our task is to learn to plug into this personal angel. Our twin, having access to the wisdom of the ages, can tell us what to do so we'll never be at a loss. We just have to learn how to keep the passage between their mouth and our ear lubricated and clear.

Lorna had also given the study group some bold new information about the old days, when the Big Book was being written. She said that the men who wrote the Ten Commandments, including the seventh, "Thou shalt not commit adultery," were all polygamists. Jerry seemed very struck by this. In retrospect, it seems an ominous piece of information to stick in a husband's mind.

Jerry invited Sister Lorna to dinner. She arrived on a plum-soft June evening, in a big white Cadillac with a zebra-striped interior. She was a large woman and wore a big white suit, with various tactful drapes over her whopping bosoms and big butt. She had a sticker on her car that said, MEAT WEEPS. *Oh, shit,* I thought, remembering the crown roast in the oven. It smelled rendingly delicious.

"How is your name spelled?" she asked me when Jerry introduced us.

"B-e-l-l-e."

"May I call you Bella? B-e-l-l-e always makes me think of Belly." And Lorna laughed ripplingly.

"Well, L-o-r-n-a always makes me think of *freaking moron,*" I said, but only to myself.

Jerry was wearing broad purple suspenders I'd never seen before. He was scrubbed so clean that his ruddy cheeks shone. When we sat down at the table, he carved the roast. He looked doubtful and apologetic as he offered it to her. "Do you eat meat? Will you have—"

"A slice of corpse? I think not," she said, and laughed merrily again. But in the end she ate a lot of the roast. We drank a lot that evening. A pungent aroma of smoke and blood filled the kitchen. The roast had been rare, the kind that makes you remember that *carne,* meat, is the root of *carnal.* Lorna's beestung lips (siliconed, I thought) gleamed with oils and juices. Very late in the evening I noticed how silent Jerry had become. He watched as Lorna wrapped those lips around seared suet, hunks of Roma tomatoes, the blue veins of soft-reeking cheeses. She noisily sucked and nibbled her way through meaty bones, bulbs of green onions, bittersweet chocolate leaves on the Queen of Sheba cake. I have to admit that woman knew how to enjoy a meal. She put her whole back into it.

Jerry watched her. It had become very dark in the room, and I was thinking I should turn on the overhead light when Jerry suddenly got up and went to the counter. He put several small candles on a tray and lit them. In the darkness he brought the candles to the table and set them before Lorna like an offering of flowers. I was confused at being left in the dark and by the dazzle of their two bright heads above the flares of light.

After that, Lorna would often swoop by on especially beautiful summer evenings. She would accept iced tea and converse. Immaculately clad in a white sundress with a sweetheart neckline, she made the wicker lawn chairs creak. Once she laughed so hard at Jerry's jokes that her nose bled. I think it was that evening that she bethought herself of some church business that needed Jerry's immediate attention, and she bore him off in her white Caddy.

As she cropped up night after night, her wild Nordic head flaring in the red dusk, I came to think of her as a Viking raider. It seemed to me that those big, terrifyingly direct turquoise eyes were fixed on my one treasure. But Jerry said Lorna only cared about God and Jesus and was obsessed with interpreting their will through her angel twin.

Five years before—hell, a year before—I would have laughed at the idea of loving a man who could make a statement like that. But not now.

What is it for: this fierce particularity of yearning, which makes incandescent one human object and no other?

Jerry had always had a wonderfully hot, carnal attentiveness. Now he grew cool. He was increasingly silent and distracted and in the twilight would look down the street in the direction Lorna's Cadillac might come. He watched the street like a dog.

It was during this period that I found a press-on nail stuck to his underwear.

I said nothing to Jerry about this. Instead, I spent a great deal of time driving around in my car with the radio on. Country songs, the kind I'd always made fun of, spoke directly to my condition. *I know he doesn't treat you right. I see the tears you try to hide.* I changed the station and got Buddy Holly singing "Slippin' and Slidin.'" *Don't want to be your fool no more.* Some hope. I rotated the dial. It started to rain hard, and just then Bessie Smith wailed suddenly, *oh it was honey this and honey that and it was baby my baby all the time.* She also sang a song about a woman who murdered her husband. *He wallowed around and then he died.* It seemed to me that this was a good representation of the human condition in general. You wallowed around, and then you died.

I thought a bookstore might cheer me up. The big Waldenbooks was open. As it turned out, there was a huge pyramid of Lorna's best seller, *Let the Angels Call the Shots*, in the front window. I picked up a copy and looked at it. I was interested in the mental makeup of someone who thought the angels told her to ball my husband. *Thou shalt ball Jerry.* Truly God must be everywhere. I looked at the chapter headings. The one called "Love Yourself Tender" caught my eye. I turned to it. Lorna was a big believer in self-love, or more precisely, being crazy about yourself. You deserved, she explained, the absolute best of everything and should always think of yourself as the guest of honor at life's banquet. I thought of Jerry buck naked on a huge silver trencher at her table, an apple in his mouth. Lorna said that, to signify her complete self-love and self-acceptance, she began every day by giving herself a great big hug. Everyone else should do the same.

I put the book down. Tentatively, I encircled myself with my arms. Was I doing it right? I felt thin. My heart beat gravely beneath my wrist. After a moment, in a movement that felt irrepressible, my shoulders hunched and my chin drew down to my chest. I closed my eyes. I stood there for quite some time before realizing that people, a lot of them, were staring at me. A man said in an interested voice, "That's the first time I ever saw anybody sleep in the fetal position standing up."

I drove around for a long time, then bought a bottle and drove to the store. I let myself in. I got drunk. In fact, I hadn't been this drunk since college, when one night I mistook my roommate's open bureau drawer for the bathroom.

My memories of that night in the store are hazy, but I clearly remember a moment toward dawn when I stood in front of the glass honey vat, with my face over it. I was attempting to weep exactly three tears into the vat—not two, and not four, but three, which for some reason I thought was the appropriate number as laid down by fairy tales.

When I drove home that morning, I discovered Jerry and Sister Lorna in the shower together. I reached in and turned off the cold water. Followed by their tornado-siren shrieks, I walked into our bedroom, hauled the big mattress off the bed and down two flights of stairs, and burned it in the front yard. I was interested to see how quickly the police showed up. We'd been robbed the month before, and that time it took them much longer.

The profoundly shaken, scalded Jerry demanded a divorce. At the hearing, the judge left us alone for fifteen minutes to see if we could reconcile. The reconciliation got off on the wrong foot. Jerry mentioned at once Lorna's belief that, once in every generation, there is a reincarnation of the Great Beast of Revelation. She thought I might be it. I responded that Lorna was a moronic slut, and if she didn't keep her fat ass out of my life, I would drink her blood like wine. Jerry looked horrified and yet oddly satisfied. Apparently I had spoken exactly as a Great Beast should.

The remaining fourteen minutes and forty five seconds we sat in silence. At the last possible instant, as Jerry got up, he looked at me and said, "You may not believe it, but I'm sorry for you. I'm sorry you have nothing and no one." Then he walked out of the room.

It was true that I had no one. Not a person in the world cared if I lived or died.

But Jerry was wrong when he said I had nothing. A conference with lawyers had been scheduled. Six hours into it, when all had been said and done, when Jerry shouted until blood vessels burst in his eyes, and he threw a leather armchair at me and stormed out of the room; when his lawyer retired wordless and gutted, and my lawyer looked at me with exhaustion, but great respect, and said, "Do you mind if I write this case up for the *Law Review*?"—at the end of the day, when I walked out of the courthouse alone, I owned the store.

Julie King

Energy

My wife is terribly unhappy here; she sees herself in the smoky glass of each skyscraper, and what she sees is a woman with spreading thighs, low-slung breasts and a bad perm. That's how she explains herself to me when she wants to move back to Wisconsin; these attributes are not only acceptable but commonplace there. I know she compares herself to the Dallas women, bedecked in turquoise belt buckles and eyelet blouses, who can afford to have their nails tipped. And when she comes home from shopping, I know she blames me for her blue moods. She doesn't actually say it, but her actions do. She places my dinner plate a little too far away from me, so succotash falls from my fork onto the table, and she sighs loudly. I allow her this; I won't move the plate myself. She blames me for the move to this transient city, for not making enough money to allow her to have her toenails done even though she won't wear sandals. Her feet are wide and knobby, she says. I suppose that's my fault, too. I'll take the blame.

What my wife really wants I can't give her. She wants a child. We have been married for eleven years, and every month for nine of those years she has raged against the forces that gather blood inside her, only to release it again in torrents. Sometimes I think she is dying by the number of bundles tossed in the wastecan each month. Sometimes I think I am the one dying. She refuses testing, refuses to discuss adoption, refuses to visit any friends who have children. I suspect she refuses testing because she wants to be able to blame me, my defective sperm. I'll take this blame, too.

I'd like to tell my wife we'll never have children, she'll never conceive, and each act of lovemaking doesn't have to be a desperate friction of skin, a banging of pelvises, bruises over her thighs in the morning. I will never tell her that I don't ejaculate anymore. A few moments into intercourse—for that is what our making love has become—I soften but then grunt, sweat a little, and kiss her neck with the pretense of pleasure. I know she enjoys none of these animal acts. She doesn't care that she's not satisfied. She only thinks of sperm tumbling and rolling toward her ready egg. I think, when I watch her face, her eyes crunched shut, she is visualizing the moment of conception, as if she can will it to happen, like a cancer patient wills away the killing cells.

So this is how we live. I work as an apartment manager, posting tenants' rents on the first of each month, patrolling the grounds every night. The job is quiet, safe, but pays very little. In the small Wisconsin town from which we moved, I was on the police force, still in uniform, ready to make lieutenant. I quit after I was shot in the head by a man burglarizing a laundromat. He was pounding a washing machine with the butt of his gun when I walked in. I had wanted to buy sodas, Dr. Peppers, in bottles, not cans, for me and my partner. I was thinking about rolling the smooth, cool bottle against my neck when the burglar aimed his gun and fired. The bullet hit my left temple, travelled under my skin, pushed its nose up through my skin and back down again, finally nestling under my right cheekbone, as if it had found its home. Doctors removed the bullet, but I have a thick, red scar that itches when I eat corn on the cob or when I smile. When I'm nervous, which is most of the time, I pick at the raised edges of the scar until they bleed. I tell my wife I cut myself shaving.

My wife did not want to move. She said the chances of getting shot again in our small Wisconsin town were a million to one. But I didn't take her opinion personally, not thinking that she didn't care about me. After my uncle offered me the job in Dallas, to manage one of his many buildings, my wife and I sat at our little linoleum table, the one we bought when we first married, a matchbook under one wobbly leg, and discussed our possibilities. Long after two six-packs were emptied, long after we made charts of the pros and cons of each choice on a pad of paper with an Oxycodone logo in the corner, my wife laid her cheek against the table and cried. The possibilities of us staying in our hometown were depleted. As she cried, a belch began rising from the recesses of my gut. I swallowed hard to squelch it, and she took my hand, mistaking my throat's movement for grief.

Now we live life, waiting for it to be over. I wake at seven and watch my wife sleep. She breathes so lightly, so silently, I wonder if she really sleeps at all. I think she stares at the pimpled ceiling, memorizing its white vastness, and at three seconds to seven, before I glance over at her when I wake, she closes her eyes. I place my feet on the floor and get my bearings, studying the sparse black hairs around my nipples. The hairs wriggle and crawl as I stretch, and still my wife has not made a sound or moved. If I turn quickly, will I catch her studying my back, the back she used to lay her cheek against every morning? I don't dare turn around, not wanting to disturb the air.

I pour myself some day-old coffee, take in the early morning heat, and wait for my nerves to sing. When I drink pots of coffee, I feel my head is detached from my body, that my vision is sharper—lines of chairs, dishes, the angles of my wife's cheekbones, are more pronounced. I feel my fingers zing; if I spread them before my face, red flashes bounce from one finger to the next. I feel I can see into the skulls of others around me, into the place where thoughts begin, swells of colors, blues and reds, gathering into images and equations and lines of poetry. I tried to explain this to my wife one morning as we sat for breakfast. I told her I could see the formation of her decision to either clean the kitchen or get her hair cut that day. She clutched the handle of the coffee pot.

"Is this new age thought?" she asked.

"No, it's energy. Mine and everyone else's."

She sighed and looked out the window, hoping to see a new life coming up the street in a Corvette. "Use some of that energy and cut the lawn."

Today I only drink four cups. I don't have a lot of work to do or the desire to read others' thoughts. It's mid-month; all bills for the apartments are paid, all rents are posted. I sit in my air-conditioned office, waiting for a toilet to plug up or a wall to fall down. Hours later I note that I missed lunch. I note my hands tremble with anticipation of work, of duty, for my night rounds to begin.

At the moment day meets night, I see an explosion. The heavy weight of darkness slams onto the cool weightlessness of light, and the friction causes blue sparks. I don't tell this to my wife. I thought for a short time that I was crazy when I'd have these thoughts, that the sameness of days had upset the balance between mania and depression, that I was falling more deeply into the latter. But the logic of my random thoughts became clear to me when my wife and I watched television one night.

"Your scar is throbbing," she said.

"What?"

"It is. It's jumping up and down like a jumping bean."

I touched my scar, my blood raging there, and wondered if my scar somehow allowed me to tap into another realm. I accepted the pattern of my random thoughts from that point on.

Before my night rounds, I go home to my wife. She sits at the table, perspiring, drinking coffee and swinging her foot. She had polished her toenails, but the polish on her left big toe is chipped. The remaining polish is an island floating on the expanse of pink skin. Steam lifts the covers of pots on the stove, and she spoons carrots, broccoli, and corn. Her meals are always colorful, always varying in shape and texture. When we first moved to Dallas, she used to dream of white dinners—turkey, mashed potatoes, rolls with butter—and would wake up vomiting. When she knew beyond the shadow of a doubt the vomiting wasn't morning sickness, she planted a little garden in back of our apartment, in the middle of one sultry night. I was the manager; she was allowed to dig up the grounds and plant lettuce, tomatoes, whatever grew for her. Now she spoons orange, green, and yellow onto pink plates. Our dishes are pink, placemats yellow, tablecloth splattered with tropical colors, peach and turquoise. I can't tell her these colors put me on the verge of a migraine. I accept that this is where she gets her energy, but I want to tell her that white—clean and stark—would aid in digestion, would put her dreams at ease if she believed hard enough.

I eat. My wife swings her foot. We have come to this. Soon it is time to make my rounds of the apartment grounds. I love this time in the evening when lights begin to turn on in the apartments, when my residents are settled in for the evening, secure that the darkness will remain outside. My apartment complex is populated with quiet, retired folk and young married couples, some with small children my wife avoids like the plague. No frills here, just clean, safe places to live, with a clean, safe manager to watch out for all. Many residents sit on their porches until I pass on the first round. We chat about the Rangers. Heat. Lack of heat. Rain. Lack of rain. Flowers. Wilting flowers. I like this, the pure cyclical nature of this.

Tonight is quiet. And hot. I see Mr. Bailey's head behind his shade in silhouette. He and I share books and discuss them on my rounds. I pass Bill and Tina's. They are newlyweds, not ready for the demands of marriage. Sometimes I see her crying, in the darkening, her life encased in brick and cracking mortar. I want to tell her this will pass; she'll settle into the pure lull of it all. But I know the buildings are breaking down, not from weather or age, but from forces inside, emotions and screaming and silence. My own walls suffer hairline fractures from what is not said between my wife and me.

A few curtains are not yet pulled in the half-night. Mr. Linden's are partially open. The times when he sits on the porch, waiting for me, his hand on the head of his cane trembling with the weight of old bones, I shout to him. "I'm here! I'm here!" His head shakes violently, as if a mosquito buzzed there. I know he can't hear me, but I scream anyway, exalted by the vibrations in my throat. Then I put my hand on his, and he lifts his in greeting. I stare into his eyes. He is blinded by blue films of cataracts. I wonder if he sees outlines of the world within the blue, as if we're all underwater, swimming aimlessly. I am afraid of this; I don't want him to see me drowning.

Sometimes Mr. Linden's granddaughter sits outside with him. Eleanor is a big blonde Scandinavian girl, a social worker whose thick teeth show when she talks, which is all the time. She comes by his apartment three, four times a week to relieve the live-in nurse, to clean, cook vegetarian stews, read her grandfather thick, tattered novels she has kept from her school days. Sometimes I sit on the steps while she reads, her voice smooth as bottled glass, her thick teeth revealed when she lifts her blue eyes to me and smiles. Sometimes she wears cut-off jeans, men's thin-strapped undershirts, heavy breasts untethered, blonde hair soft under her arms. At times like that, I want to crawl into her big, generous lap, to be blind in her arms.

Right now I want to see her, to feel the energy of the extra blood she carries in her strong body. I don't want to look inside Mr. Linden's apartment, but the window emblazoned with light, the half-opened curtains compel me to. I should knock on the door, but the promise of light means the promise of Eleanor. The nurse, when she is there, reads in the extra bedroom, using only a lamp, no other lights in the house. The nurse is frugal; why turn on lights when Mr. Linden can't see? Eleanor revels in the possibility that light may enter Mr. Linden's head and give him internal sight, images floating on the inside of his cataracts, memories and dreams. I need the light she provides; the darkness is smothering me. I am so close to the window by this time that my toes butt against the building. My hands clutch the windowsill. What I see inside dances before me until I am dizzy with sheer speed.

Eleanor, naked and natural in the heat, crouches next to the table, her chest slick with sweat, slowly spooning something into Mr. Linden's mouth, something steaming with gravy. Her large breasts sway with each motion, and the ends of her light hair tickle her pink nipples. She swivels toward me, oblivious of everything but spooning the last morsel of nutrients for her grandfather, and I glimpse the soft curls of her vee, the pink of her lips, a blooming rose. Mr. Linden's throat warbles with nourishment, belly feeling the fullness, eyes blind to this beauty that I witness. I feel my heart break.

I run to my apartment, willing cooler air into the fibers of my clothes. I try to form words I will tell my wife, try to form them before they form themselves in the center of my brain in purples and pinks. Images float in the air: my wife rising from her bath, skin oiled, hair waving from the steam. My wife working in her garden, hair waving from the humidity. I love her at these times, when she doesn't know what a beauty she is. I've never told her this. I want to tell her she is a beauty, leaning against the counter, holding a cup of coffee whose steam blurs any hard edges on the planes of her face. I can't form the words; I only stare, my scar throbbing. She tucks her hair behind her ear self-consciously, her fingers small spades. As her fingers run through her hair, creating even rows, I think flowers will bloom there. I still stare, and she pours me some coffee, in a mug that spells out her name in cartoon letters, and as I drink deeply, covering the letters with my palms, I hold in the warmth, hold in the sparks of her energy.

Carol Sklenicka

Putting Up Storms

Scott Conley stretches out on the rug across from Joe, his friend now since seventh grade, and breathes in the steam from his cocoa. They've finished putting up the Conleys' storm windows this blustery November afternoon, work Scott enjoys because he loves the picture it gives him of sheltering his family from the onslaught, the slashing pain of winter. With good storms in place, a solid house like theirs might remain livable for eight to ten hours after a furnace breakdown.

Scott's wife, Gail, made the cocoa as a way of asking them not to have beer, and Scott wonders if Joe will comment about this. They're watching the dreary end of a Badger game. Joe wonders out loud how some of these ball players get mixed up with drugs. Scott shrugs.

"Listen for Amy," Gail interrupts. "I'm going to the store. She can have her bottle if she wants." Gail has her coat on and her purse on her shoulder, ready to make a run for it, before she adds, "She could be crabby—she's slept a long time."

As the garage door grinds down, Amy erupts with a long, sad wail that sounds like a train whistle coming closer in the night. Joe follows Scott to the crib. In Scott's arms Amy is sweaty and sour and inconsolable, squirming but clinging at the same time. On her back on the changing table she looks at him from black-brown pools in the middle of her incredibly white eyeballs and kicks her warm, fat brown legs. Amy is fourteen months old, but Scott is still scared to death of her. Especially of the tenderness between her thighs that always astonishes him—fat labial cushions ever so slightly puckered by the diaper's dampness, a barely visible purpleness within. He cleans her lightly, not quite looking at his hand. Joe's watching, and Scott wishes he weren't.

"You don't deserve that little girl, you know," Joe says, apropos of nothing. The remark makes Scott's arms weak and disorients him. It's something he's thought himself, thought and rejected. His head is spinning.

He sees bruises on the pale thighs of that girl in ER last week, the blood and feces on her panties. He raises Amy by the ankles, centers the clean diaper under the wedge of her neat bottom, pulls it between her legs, tapes it down snug, very snug.

Scott wants to put more than padding and plastic between Amy and the world. He wants to put her into steel diapers and carry the key. He doesn't mention this to Joe. Amy wails and thrashes so hard that Scott's enfeebled arms can't get her legs back into the sleeper.

"Let me try," Joe says. "It's been a while, but—" and he's already slipped one leg into the non-zipper side and worked the plastic foot over Amy's. Joe crooks the other knee to insert it into the other pajama leg, and Scott notices how he instinctively shields Amy's delicate skin from the vee of the zipper. Joe holds her foot a minute, touches her toenails, which are thin and translucent as fishscales.

"Un-fucking-believably beautiful, aren't they?" he says. Scott thinks Joe, usually the perfect gentleman, swears to impress him. He first noticed this when he returned from the war and Joe was still in college. A lot of college kids began swearing like infantrymen at that time, as if they wanted to have linguistically the experience of hell they'd otherwise avoided.

Joe puts his face on Amy's naval and makes a noise like a party whistle. He toots her tummy button a couple times, and Amy stops crying long enough to listen. She catches her breath. Lumpy scars on Joe's neck remind Scott that when they were kids Joe had the worst acne.

Joe pushes Amy's second foot into the sleeper, zips her up like a suitcase, snaps the tab at her neck.

"Your baby, mister," he says, swinging her to Scott.

Scott takes her like a crystal vase. His forearms are so tense that he can feel muscles twitching in them.

"Time for the flipperoo, old man," Joe declares.

"What's a flipperoo?"

The girl in Scott's mind is a 12-year-old rape victim, a late night call-out for Scott. Usually he doesn't have to meet the victims with their clothes off, but the ER room at St. Luke's was crowded, and the doctor had never done a rape exam before, so Scott had to be responding officer, detective, and nurse, all at once. The girl's mother's husband's uncle was the perpetrator, and he'd violated this little girl pretty roughly, left Scott all the evidence he'd need to put him away for a while—bruises, blood, semen. It was midnight before they finished, so Scott brought home the evidence kit containing swabs and hair samples and the girl's soiled panties, white with faded pink flowers. Because the night was warm, he stored the envelope on a lower shelf of the refrigerator.

But in the morning when Gail reached for Amy's milk and asked what was in that bag, he felt his mistake. Gail scalded the milk (a step they could skip now), added water to cool it, and got Amy all set in her high chair before she handed Scott the lidded yellow tippy cup and ran to the bathroom. Scott heard her retch several times and run water to clean up, but she didn't say a word when she came out. She put her face against his chest and hugged him around the waist. "Was it a bad one, honey?"

"Pretty bad," Scott said. Early in their relationship he told Gail he never talks about his work, so she doesn't probe, but sometimes he wishes she would. His co-workers in child abuse are women, and women cops tend to act tougher than the men. They don't talk about what these investigations do to them. All that day Scott was vexed by the thought of his daughter's milk contaminated by that creep's jism.

"The flipperoo. First assignment in Parenting 201, buddy."

"Parenting? That some new Scandihoovian sport?" Scott hates pop-psych words, and as a post-seventies cop, he's heard plenty of them. He hates them because they don't account for the way that girl's crotch looked in the ER. But Joe's credibility as a dad is fine—he has four kids now, one girl already a junior at Divine Savior, the rest coming up through parochial schools—good grades, sports, no problems.

"Those are the best kids you could ever want, all of them," Scott used to tell Joe, but Scott didn't want kids. Before he had his own, he cared nothing about other people's kids except professionally. "How's the rug rat," he'd ask, and barely listen to answers that usually involved ear infections or teething or strep throat. Who needs it? he said to himself. Something relentlessly wholesome about young fathers bugged the hell out of Scott.

His own father was a drifter, first by occupation—he was a highway construction worker who moved from job to job—but perhaps also by nature. His mother owns a fuzzy black and white photograph, an enlargement, that shows her sitting on a train holding Scott up for the camera: a big baby wearing a knitted cap, legs flexed against her thighs, eyes dark and bright even in that poor photograph. "That was when I was going to visit your father in Alaska," she said. She had been married to him then, but not for long, and, as Scott pieces the story together, his parents never shared a residence after that visit to Alaska. There had been no picture of his father in his mother's house, only this other one that represented his father as a destination.

His mother told him his father lived with them on the top floor of a big, blue Victorian house with a cupola when he and his sister were young, but she said it with the same detailed, irrelevant wistfulness that marked her rendition of walking to work when it was 20 below in Black River Falls or of watching Kennedy get shot while she was tending bar and couldn't even stop serving drinks long enough to have a good cry. For her, loss is the motif of her own and everybody else's history, the only thing that makes it real.

"How young were we, Ma, when Dad lived with us?" Scott used to ask when he was about eleven, clinging to last shreds of boyhood. "Six? Five? Was my sister even born yet?"

"Yes, she was born. We all four lived together, had dinners together, went to the drive-in movies with you kids in the backseat in your pajamas."

Maybe, but Scott has no memory of it. The few memories he's sure of don't support his mother's stories. His sister was born in '49; he remembers that well enough because he was sent to stay at his grandparents' in Door County. Why wouldn't he remember his father's presence?

A father's failings recur in his son, Scott suspects, and the psychology he's studied doesn't contradict this. He knows he's not meant to be a father.

Joe is never plagued by such uncertainties.

The worst thing Joe ever did in his life was get Marty pregnant a couple of months in advance of the wedding. Joe was at Madison then, and he stayed in school, working nights to support his family and refusing to let Marty get a job out of the house. They managed the apartment building they lived in. Scott was a rookie in the police department then and recovering from a disastrous post-Vietnam first marriage by sleeping around as much as possible. A couple of times when he had a new girl to impress, he brought her to Madison for the weekend and borrowed a semi-furnished apartment from Joe and Marty. Marty even provided clean sheets. To repay them, Scott would do a few hours of painting or cleaning on Sunday while his lady friend checked out State Street. Marty kept her distance, but Joe got a kick out of having Scott as his rogue friend. "Lady killer," he used to call him. It didn't bother Scott, who figured it was natural for Joe to be curious since he'd never had a single life himself.

When Joe's first daughter was about six, she noticed that the woman Scott brought for the weekend wasn't the same one as the time before. Joe pulled Scott aside and told him he wouldn't be able to borrow apartments anymore. He tried to blame it on Marty, but his own distaste was evident. "Maybe it's time you found a decent girl and settled down, Scott. Who knows? Maybe it's not too late."

"Too late for what?" Scott said.

"Oh, you, know. To be satisfied with one woman, I guess. I don't know. I never really understood guys like you."

There was a hiatus in their friendship after that, half a dozen years or so, the years in which Gail began deliberately turning his life upside down. Then Scott broke the ice by inviting Joe and Marty to his wedding—without the kids, but not without a certain "so thereness" intended.

By then Joe was a manager at Miller Brewing, and Marty seemed to have discovered birth control. Joe and Scott drifted together again—for a beer after work or to watch a game. When Scott moved to the child abuse section at the MPD, Joe started peppering him with questions—what kind of families they were, how the mothers let it happen, how anyone could prove anything. And, mostly, how Scott got interested in the field. Joe's comments annoyed Scott by making him feel that he was responsible for the crimes he investigated. Still, Scott took them as he used to take Joe's curiosity about women he went out with—as inquiries from a man whose own life had to be boring. Just knowing somebody who dealt in that world of slime must be exciting for Joe.

When Gail and Scott bought their first house, a fixer-upper in Sherman Park, Joe helped more than you'd expect. All three of them had fun together then. Joe would bring over his free cases from Miller, which he said would go to waste at home, and Gail drank right along with them. Joe would back Gail up when she talked about the kids that would live in these rooms someday. Once, after Gail left the room, Joe winked and said, "Don't deny her those babies, Killer."

Now Scott wonders if, by spending all those hours drywalling and plumbing, Joe was escaping the pandemonium of Saturdays with four children. That's hindsight about Joe. At the time Scott saw in Joe the perfect dad he would never be himself.

Scott carries Amy to the family room; on screen they're doing post-game wrap up. Joe hits the mute button and lies down on the floor and raises his sock feet to form a pedestal in the air. "Okay, hand over that baby."

Scott looks at his friend's hands grasping for Amy, his wedding band and clean nails, hands that have never been anywhere they shouldn't have been. He feels Amy's well padded bottom on his own forearm, her sweet sour breath in his face.

"I can do it, Joe. You just talk me through." Scott lies down on the floor next to Joe, bends his knees, sets the baby on his stomach. He's the one in changing table position now.

Amy has on a soft one-piece blanket sleeper, carnation pink with a design of darker pink hearts and flowers embroidered over her own heart. The sleeper is new; Gail commented on that when she buckled Amy in her high chair for her Malt-o-Meal this morning. "We're not going to dribble all over this pretty, new sleeper now, are we?" she'd said in the little voice they both use when speaking to Amy. Because it's new, the sleeper is too large. Amy looks tinier than ever, particularly where her surprisingly strong neck emerges from the suit.

Joe stands over them like a coach. "Now, you just lay her stomach on your feet and hold on to her hands." Scott raises his feet and places his hands under Amy's arms, nearly circling her shoulders. She's balanced on his feet. His heels are under her hipbones, and his toes press her ribs. Scott would give anything to lose this anatomical response to other bodies, but he knows he won't. He's already seen too many dead and damaged human beings.

He's thinking this as Amy begins to laugh. To crow, really. "DaDa! DaDa!" Her eyes are wide, and drool drops a silver line from her beautiful wet smile to his shirt. Joe has quit coaching, but Scott knows what to do next, as if his body remembers this from somewhere.

He sways his legs back and forth and envelops her tiny, warm sweaty fists in his own bigger hands, holding tight enough so her hands can't slip away but not so tight that he hurts her. Then he flips her. She spins in the air and lands lightly on her feet above his head. She's still laughing as she crawls to the other end of him to clamber up the mountain of his knees.

"Dada, do again!"

When Gail comes in with the groceries, they're still doing flipperoos. "What a happy girl!" Gail says in the little voice. "What's Daddy's secret?"

The beeper goes off about eleven that night, after Gail and Scott have snuggled in to watch a movie. St. Luke's again. Dead baby, suspicious circumstances, more than suspicious bruises. Gail watches Scott get dressed, brings him his gun from the locked cupboard. Together they check on Amy. Scott bends far into the crib to kiss her forehead, then pats Gail's rear end, which is maybe a little broader than it was before the baby. Suddenly he's horny as hell and wants more than anything to stay home and make love to this woman he's married against all odds, against all personal wisdom and family history. He pulls Gail close to him and hopes she'll feel his hard-on, takes a chance she won't be more shocked than he is by this inopportune display of desire. He wants her to ask him to wake her up when he gets home.

Instead Gail pulls him close to her and squeezes his butt in the way she knows drives him crazy and she hardly ever does anymore. "Is there time?" she says.

There could be. That baby's dead, after all. But Scott needs to see whoever brought the child to the ER before they've realized what kind of trouble they could be in.

"It'll keep," he tells Gail, knowing he won't have the heart to disturb her the four or five hours from now it's likely to be.

The sun's glinting off the Milwaukee River as Scott drives home. He's spent an extra hour at the station dictating his report so the D.A.'s office can move quickly when the autopsy results come in Monday. He opens the

Sunday paper on the table for Gail and loads the coffee maker for her. He showers. Cleaner, naked, and exhausted, he stretches between their daisy-sprinkled sheets and wonders how life goes on. He feels his penis stir against the crisp cotton and knows. And wonders why.

When Amy's morning cry breaks his sleep, Scott's having this dream: in the house where he and his mother and sister used to live, that horrid house with the asphalt siding on Franklin Street, he is a young boy, reaching up to repair a shower rigged above the claw-footed tub in that always-cold bathroom. Pieces of pipe break off in his hands. Rust and sludge run along his arms and into his armpits. A girl about twelve, looking as if she's hidden small tangerines under her T-shirt, comes into the room. Takes the old pipes from him. At her touch they turn into shiny, white, modern tubing. The girl, who is Amy, repairs the shower and turns to him with a smile. "It's all right now, Dada," Amy-in-the-dream says.

Scott reaches for Gail, who sits up and rubs his neck as she asks, "When did you get home?" before she goes to lift the baby, who's crying into her new day.

David R. Young | Summer Snow

It was June, and cotton from the roadside trees floated in the wind like snow. My grandfather drove down from the ridge to meet me at the station in a black Plymouth that was at least ten years older than any other car in the parking lot. On the platform he struggled with two hard, boxy suitcases my father had packed for me. These had been my father's suitcases in college, and the leather grips were nearly worn through. There was more clothing than I thought I would ever need.

I'd just come west on the B&O to Wheeling, West Virginia, and then, in the afternoon, south through the hills and strip mines of southern Ohio. On the way to Pendarvis I'd been humming train songs, the kind my father liked to play—country and western songs—though he seldom played his records in our apartment. My mother couldn't stand C&W, so he kept his stack of LPs hidden away in the back of the hallway closet. Most of the songs were about treachery. My grandfather had a few words outside the depot with a dark-bearded man in new, stiff overalls and then climbed into the Plymouth. The veins on his hands bulged as he gripped the steering wheel. A thin man with a graying crewcut and narrow red face, my grandfather looked uncomfortable in the white shirt he'd worn to the station. He said he was glad to have me visiting and said little more. I said I didn't want to spend my ninth birthday alone on the farm, and I wanted to know where my mother was.

The sunlight over the fields was soft and drowsy, and shadows of clouds moved slowly. I slid over on the seat and sat as close as possible to the door on my side, holding with both fists the bar between the open window and the ventilator, tilted outward.

Above the noise of the rattling Plymouth, my grandfather spoke for the second time.

"Your Aunt Caprice has made us a strawberry pie," he said, glancing in my direction. His eyes were blue and watery, and I thought he might cry. The man always seemed to have this expression, whether because of shyness or allergies or just the color of the eyes, I didn't know. "You remember your Aunt Caprice, don't you, boy?"

Of course I did. Though on three previous visits, when I'd gone to the farm with my parents, Aunt Caprice had chosen for the most part to stay in her room. She was older than my father, but she lived at home with my grandparents. My father would never tell me why. Aunt Caprice helped with meals and set the dinner table, rarely speaking but occasionally falling apart with an outburst of profanity, usually no more than a few words. Then she would be quiet. It was her glasses I remembered best, thick as the bottoms of soda bottles.

As we climbed away from the valley, I watched the world I had known disappear. In time I would come to know the timothy grass, birdsfoot and wild asparagus covered in dust by the side of the gravel road.

Near the top of the ridge, the steep hillside farm came into view. My grandfather parked in a ditch, and I followed him through a wooden gate to the small, two-story farmhouse, covered with brown asphalt shingles. Grass grew between the red bricks of the sidewalk, and somewhere in the yard hidden flowers smelled like the curry in my mother's kitchen. The breeze, always busy on the ridge, stirred the leaves of two large maples.

My grandmother rose to greet me from an A-frame wooden swing on the lawn by the grape arbor.

"Stevie, we've been waiting for you. We've got supper ready." She wore a loose-fitting house dress with a pale floral pattern, the large collar open at the neck. The dress fell to her ankles, above brown lace-up shoes. "You must tell me all about your trip."

But I wasn't in the mood for talking. Intently, she leaned over to straighten the collar of the white shirt my father had made me wear on the train. My grandmother was a bony woman, with sharp features. She'd been a schoolteacher in her younger days and remained stern in demeanor, though the skin on her face was so tight she always appeared to be smiling.

She took my hand tentatively and led me into the yard through the sweet-smelling shadows. My grandfather, in his white shirt and best pants, was already back in the fields.

"Come inside," she said.

At the kitchen sink she pumped a large wooden handle until water appeared in the spout. She washed her hands with a bar of rough, brown soap. I was expected to do the same. Then my grandmother led me through the tiny dining room where the table had been set with a white lace tablecloth and harsh blue china.

The living room, facing west, was hot from the afternoon sun. A small desk fan near the partially opened window barely moved the air.

"Why not take the rocker?" my grandmother said. "A long journey can be wearying."

There were two caneback rocking chairs in the little room, but one was occupied. Aunt Caprice rocked slowly. The dark, square frames of her glasses hid her face, and her short brown hair looked thin and wiry. I thought I heard her whisper my name and laugh, softly, in an embarrassed sort of way. For as long as I'd known her, she had been far away and unfocused, her eyes—blue, like my grandfather's—swimming behind the thick lenses of her glasses.

My aunt's laugh was shy. It seemed there were many shy people in the family, myself included. I'd come to think my uneasiness was a trait of my father's people, for my father, too, appeared to be uncomfortable in social situations, even when just talking to the other tenants in our apartment building. He often seemed overwhelmed by the fast talk and high spirits of my mother.

I sat down in the empty rocking chair, and my grandmother settled into an overstuffed sofa.

After a long silence, my grandmother said, "Caprice, would you get this young man a cool drink? Something to wet his whistle on?" She patted her silvery hair, which was combed back into a tight bun.

Aunt Caprice did not reply and made no effort to stir.

"He's come many miles today," my grandmother continued. "All the way from New York City."

"I know where he's from, Ruth," Aunt Caprice said. "You were in the kitchen. Get it yourself."

When she realized that Caprice was not budging, my grandmother lifted herself with the help of the sofa's armrest. She walked stiffly.

"Must you behave this way?" she said, walking out of the living room.

"Shit on you," Aunt Caprice said, barely above a whisper. I was hoping the remark was meant for my grandmother and not me.

We sat rocking together, without speaking. The only sound was the desk fan and the slow creaking of the rocking chairs on the braided rug. Sweat was draining into my eyes. In the deepening silence I thought of the brilliant, nervous laughter of my mother and of our trips across the East River to Chinatown, where, in a one-room shop, she purchased the silk dresses she liked to wear in summer. Sometimes a gentleman friend would accompany us.

"What if a woman can't have no babies?" Aunt Caprice said. She laughed quietly to herself. I never understood what she was talking about.

My grandmother returned with ginger ale and a few leaves of fresh mint in a tall, perspiring glass. I looked around the living room. Little had changed since my last visit to the farm, two years earlier. Only the portable black-and-white TV set, a recent Christmas gift from my parents and now situated on top of the radio cabinet, seemed new.

I turned toward my grandmother. "How long will I have to stay here?" I asked.

"I don't know, Stevie," she replied, more sternly than she'd perhaps intended. The world was still her classroom. "Your mother needs to be away for a time, by herself. She needs rest."

"Where has she gone?"

"I don't think your father knows. That's the truth, son."

I remembered past evenings on the farm when we'd all listened to the radio together. There had been the smell of hot speakers as the radio warmed up. More often than not, the program had been the Grand Ole Opry. Even my mother, with nothing else to do, listened in. My friends back home in the neighborhood had never heard of Hank Snow or Kitty Wells.

"She's gone to Old Lyme," I said at last, "to visit Grandmother Shaw. They have a large house, with a view of the Sound."

"That's possible, son." My grandmother was fussing with her bun of silvery hair, but I couldn't see it was making any difference. "She'll be all right. Your mother always bounces back."

What she did not say was that the Shaws had not offered to take me in. It was assumed I'd go to the farm.

"Your father needs some time alone, too. He's very, very tired." It was disconcerting to see my grandmother smiling, but she couldn't help herself. "Your mother isn't suited for a family. I don't think she means anyone harm."

I'd heard it before. About how my mother had been banned from the farmhouse kitchen ever since her first visit, before I was born. She had reduced a tomato to pulp by slicing it the wrong way, the story went. My grandmother said she'd realized early on that this young woman had never been in a kitchen, and she wondered how my mother would ever raise a family. I'd heard the story every time I'd visited the farm.

Of course, my mother became a wonderful cook. She liked Indian and Chinese dishes. The story was ignorant and wrong, but that didn't stop anyone from telling it over and over again.

"The Shaws never really thought your father was good enough for them," my grandmother said. "That's no big secret, is it, Stevie?"

I wanted to run out of the house, just as, in other years, I'd run outside during the long afternoons when my father worked with my grandfather in the cornfields and my grandmother and Aunt Caprice prepared dinner. On the farm my dad liked to wear a blue chambray work shirt, and his wavy black hair was the color of crows. Sometimes, when I'd tire of running, I'd return to sit by my mother in the A-frame swing. There was the odor of concord grapes warmed by the sun and the bittersweet taste of the purple skin. We'd listen to the sound of the wind in the maple leaves, and sometimes we'd talk.

"Your father and I come from different worlds," my mother said one warm afternoon. She rubbed the fingers of one hand across the back of the other. "All that Bible teaching. Thou shalt not do this, thou shalt not do that. It drives a person crazy, Stevie."

She grew quiet. My mother must have remembered that I was serious about church, just as my father was. I was a believer. Every Sunday I went to church with my father, who always wore a dark suit and brown felt hat and, in winter, a long overcoat, the same uniform he wore to the office in Manhattan where he worked for my mother's family. Church was as important to us as the country music we both loved to play at home when mother was gone. We loved hymns by Roy Acuff and Webb Pierce. We kept the windows closed when we played our records because we didn't want our neighbors in Queens to think we were country people.

"Your father likes to pretend he's a saint," my mother continued, still swinging in the arbor. She nervously lit a cigarette. "Well, that's the way your grandmother treated him. Ed was always good, Caprice always bad. Little Edward can do no wrong. Just like the Baby Jesus, he was."

We sat without talking, facing the breeze and looking out over the valley. Below, we could see where strip mines had eaten away the distant hillside. My mother's long, auburn hair, unbound like a gypsy's, stirred in the sunlight. Supper on the farm was usually late, and this night, as on many nights, we sat on the porch swing until the grass darkened in the yard.

"They're Puritans," my mother said. "All of them. You'll see, Stevie. You'll understand when you're older."

Now my grandmother raised herself again from the sofa and left the room, and Aunt Caprice followed. She had asked me if I wanted any more ginger ale, but I'd told her I didn't want anything. In the kitchen they would make final preparations for dinner. Alone, I rocked crazily in the tall caneback chair.

The sun was low in the sky when my grandmother called me to dinner. A glistening white lace tablecloth touched nearly to the floor at the corners of the dark wooden table. The window was shut against the breeze on the ridge, and the small dining room was stifling.

My grandfather was last to arrive, washing his hands in the kitchen sink. He'd spent the last hour walking through the rows of corn in his Sunday best. In the months ahead, sitting in the dirt in the hot sun, I'd do my share of weeding in those same hillside fields.

Most evenings he would read verses from the Bible at the dinner table. That first night he merely recited grace, hurriedly. It would take him several weeks to get used to having me on the farm. The aroma of homemade sausage and hot buttery potatoes filled the small room. I thought about the strawberry pie on the kitchen counter.

When Aunt Caprice had cleared away the dishes and served dessert, she joined us again. We had coffee, my cup half-filled with hot milk.

"What would we do without Caprice?" my grandfather said, warmly, to no one in particular. It was as though he felt obliged to say something, anything. He looked embarrassed.

Aunt Caprice stared at the table.

"That's enough," my grandmother said.

"I've always said Caprice would have made some man a perfectly good wife," he added. "Of course, then we'd never have these wonderful desserts here on the farm." He rubbed his gray crewcut with the palm of his hand. "Now, Stevie, you won't be getting married anytime soon."

I didn't know if it was a question or a command.

"The boy has just arrived," my grandmother said. "Leave him in peace."

"When you do find the right girl," my grandfather continued, "you'll know it. She'll wait until marriage. And afterwards, she won't run around. It's unnatural."

"Charles!"

"Women are supposed to wait," he said firmly. "That way, the men respect them. The men don't leave them waiting at the altar, huge as Santa Claus. You know who Santa Claus is, don't you, Stevie?"

Aunt Caprice stood up and began to clear away the dessert dishes. My grandfather stopped talking. He may not have spoken so many words, outside of the Bible, in a month. I left my slice of strawberry pie half-eaten and brought the plate out to the kitchen. I offered to help my aunt dry the dishes, but she whisked me away. At moments I would see a living soul in those blue eyes, behind the thick lenses, but just as quickly Caprice would retreat.

In the living room my grandmother and I sat in the rocking chairs, watching Jack Benny. She watched the program only so she could hear Dennis Day sing. Since they'd acquired the TV, my grandmother had discovered a weakness in herself for the crooning of Irish tenors, not so different from the country music she'd always loved. Sometimes the picture flickered, but the voice came through clearly.

My grandfather had fallen asleep on the sofa. In the evenings to come, he'd soak his right foot—injured in the mines when he was a young man—in a basin of warm milky water while he watched TV.

I didn't notice that Aunt Caprice had joined us in the living room until a commercial break. "Red Skelton's much funnier," she said, just loud enough to be heard. "Shit on Jack Benny!"

She turned and climbed the stairs to the bedroom I would share with her, across the hall from my grandparents' room. I could hear her hesitate a moment near the top of the stairs before she slammed the door.

My grandmother said she was ready for bed, too, and she awakened my grandfather long enough to point him in the direction of the stairs.

"She can be horrid," my grandmother explained to me. "But we must learn to forgive her. She is paying for something she did when she was very, very young."

My grandmother moved about the small house turning off the lights before climbing the stairs. I knew I must follow, but I took a long time in the bathroom downstairs, undressing slowly and brushing my teeth twice before going up.

In the bedroom, Aunt Caprice was kneeling by the side of her bed. When she heard me, she stopped reciting her prayers and whispered, "You're the one like me, Stevie, more than the rest of them. You'll be part of our family now." She climbed into bed in her flannel pajamas. The night was much too warm for flannel.

Tired as I was from the train trip, I wouldn't sleep. I lay in my bed and listened to my aunt's breathing. Then I moved to the ledge and opened the window. The hillside breeze, softer now that the sun was down, whistled lightly through a windowscreen clotted with snow. Through the white patches I watched the farmyard darken. As night settled in, I could hear but not see the wooden gate creaking in the wind and the quiet swashing of maple leaves in the yard.

Peg Sherry

Sand Dollar

I started a new career of writing stories when I retired, so it has become easy to believe in the unexpected. Still, Ann's phone call is such a surprise that I answer in a silly singsong voice, "It's been such a long, long time." Then, mockingly serious, I add, "Even your voice is unfamiliar."

Her words come quickly, with that breathy quality she uses that makes you wonder if she might share an important secret. "Hello, you old retiree. Is all your free time hanging heavy or have you read through the whole library? Wouldn't you love to see Eric? He's ours for the weekend. I'll stop by after I get him from daycare."

I breathe in and picture Ann's narrow face, her close-set brown eyes that could turn cold on contact when someone she didn't like went beyond a brief handshake. But suddenly I see her face, my friend from the past, eyebrows arched, her wide mouth smiling its fullest at one of our ridiculous jokes.

I breathe out as her voice fills with hearty cheerfulness. "Guess who's in charge today? Ed's home tomorrow, and you know how he takes over."

When we hang up, I poke through some dusty photograph boxes. A cleaning-out mood has filled me since I retired. Each day I go through drawers and closets.

"These old pictures of our trip to Florida might help with small talk when Ann brings Eric," I tell Tom. "After today I'll toss them. We never see Ed and Ann anymore."

My husband looks at me over his morning coffee cup. "Maybe you want to keep them for old time's sake."

I jab the breakfast scraps into the garbage disposal. The sudden tears in my eyes amaze me. "I used to think we'd still get together despite her job. When I worked, I took time for our friendship."

I remember my calls to Ann at her new job.

"Sorry. She's in a meeting. Sorry, she's making a speech out of town. May I do something?" The secretary sounded efficient.

I wondered then if Ann might notice if I shouted, "Help! My job is making me shake. Hooray, I'm retiring."

Ann never made it to my retirement party. She was at a conference.

Now I mutter, "Maybe we've shared all our old stories and haven't made new."

As we look through the faded photographs, Tom teases. "There you are, a lot younger, holding onto that sand dollar. You've never used your wish."

I smile. "Haven't needed to." I glance at the bowl on the coffee table. "But the sand dollar's in the shell bowl, just in case."

As Ann puts the baby on my family room couch and takes off his sweater, I note her hair. She has tipped it. The clipped brown bob gleams in the lamp light. Her blouse is a vibrant yellow silk that detracts from the lines around her eyes. She used to like being our beauty advisor and was determined to help us both stay young. When my hair started to gray, she advised, "Stick to colors that perk you up. Pink and rose or soft gray might highlight your hair if you refuse to color it."

While she's busy settling Eric, I speak rapidly to fill the silence. "We must be getting old. History is hitting everywhere." Trust me to jump right in, speak in riddles.

In high school, she used to say, "Must you always be so obtuse?" Then she'd arch her eyebrows and smile. "You eggheads are just that way, I guess."

Ann isn't paying attention. She sets Eric on the rug, takes off his knit cap, and smooths his dark hair. He smiles when she kisses the top of his head.

I rattle the morning paper. "History Hits Mall. History Hits Mall!" I repeat the headline as though she's hard of hearing. When she raises her eyebrows, I keep going, "One of my ex-students has a theory that history affects everything, even malls. He wrote this article about the mall on the edge of town. It's closed, deserted." My words won't stop. "I must have taught him something. He spelled deserted correctly."

Ann smiles absently.

On the way to the kitchen to get tea, I slow myself down by giving Eric an old, well-used stacking toy from a chest drawer. I hear Ann settle into her chair. She raises her voice and sounds cross. "How could you, the smartest person in our class, end up teaching history, such a boring subject?"

I bang the kettle, swoosh in the water, make my voice steady. "History gives a perspective, you know, and a distance. For all we know, history's being made this very moment."

"Remember the little record shop that used to be in that mall?" she says. "We got a signed Barbra Streisand LP at the opening."

"The manager gave you the display sample because they'd run out, and he was afraid you'd throw a tantrum."

We'd told our stories this way many times, playing a familiar game that began in high school when we each desperately needed a close friend. One of us would start, and the other finish. "The Bobbsey Twins," classmates would groan, "doing their duet." It became an automatic chorus that ended in laughter. Now it feels like a tired script. If only Eric could speak, he might give us a new topic.

I give Ann her tea and add, "Even that Streisand record, 'The Way We Were,' would fit right into the theory."

"Theory?" Her voice asks the question.

"The history th . . ." I stop as she thins her mouth. Her frown narrows her eyes and deepens the lines.

We each start again with "My grandchild . . ." then stop.

Ann looks at Eric playing and says firmly, "I must get toys for his visits, but I never shop anymore. My job takes so much of my time."

Her thin shoulders straighten as though to bear the weight of her work. "Long range planning, meetings, speeches, and the Mayor wants me on the new council. I never imagined . . . But I'll stop. Other people's work is tedious to hear about."

She glances at the yellowed photos I left by her cup but turns to examine the wooden stacking stick in Eric's hand. Frowning, she rubs at the gray discoloration of the old toy, then sets it aside. "How's your Tom? It's sad we're all so busy. We never see you anymore, but then, I never see my own husband." Her voice is flat.

She has a way of moving our talk as she did my hands when she tried to teach me to knit booties for my babies. She'd click her tongue. "So smart, but such a klutz." Then we'd unravel the yarn to start again. My children would never have had homemade booties without her.

She clicks her tongue and continues. "Weren't those awful nights years ago, you trying to knit, me learning bridge. You and the men had such card sense, and I always lost. How I hated that game."

Eric pulls himself up by the coffee table and she smiles, her eyes shining. His small, chubby hand pushes and pats the round glass bowl that holds my shells. Leaning forward, he pokes at the glass, then licks it. We both laugh as he turns and looks at Ann, then back at the bowl.

"Eric sees the pretty shells." In her normal voice, she says, "Mine cracked when we moved. God, it seems we were always packing and moving . . . into bigger and better . . . Ed's dream." She looks around the room as though for the first time.

"Is that your same sand dollar, still unbroken? Remember the story you wanted us to believe about the five doves hidden inside? And the wish?"

I point to the pictures beside her. "Tom and I were cleaning out drawers. We found our old Florida pictures."

As Ann looks at the photos, I think about the ancient myth that promises that if you find a perfect sand dollar and break it to free the five doves hidden inside, you get your wish.

The year we visited Ann and Ed at their home in Florida, we searched for sand dollars. Broken shells littered the beach. It made me sad to think of all those wishes strewn through the ocean or pecked apart by shorebirds. Finally Tom found a perfect shell.

"Let's all break it and wish together," Ann announced.

"What if something happens and I need my own wish?" I half believed the words as I spoke."

"What could you possibly wish for?" She nodded at Tom searching for other shells nearby, then frowned at Ed, who stood at a distance squinting into the sun, "Who needs wishes when you have all of it—career, kids, a husband that hangs around."

I hugged her and, blinking, stood looking far out to sea. "If wishes were horses," I chanted. They all groaned, grabbed my arms, and pushed me into the water. We dunked and splashed each other until we were soaked and breathless.

Leaving the beach, Ann whispered, "If the sand dollar cracks on the way home, you'll lose your wish, but I'll still be your friend."

"I'm not superstitious." I had laughed, so sure of everything.

"My God, how young we look." Ann examines one photo intently. "Were our teeth really so white?"

She refuses to move the bowl of shells when Eric fusses about it. "He's got to learn he's not in charge. We never moved things for our kids, did we?" Her tone makes us conspirators who survived raising children. "The old pan and wooden spoon will do the trick. Don't get up. I'll find them. Talk to me about how you're filling time. How long has it been since you retired?"

Her words continue from the kitchen. "I suppose you still collect records. Don't tell me you bother with those good old oldies anymore."

I pour more tea and find a worn stuffed bunny for Eric, who immediately chews at it. "We still listen to the LPs we like best but . . . actually, we're into lots of new things since I retired."

Would she really care about my writing classes or tossing out the spoons? One morning I picked up a coffee spoon at breakfast. It looked discolored. I picked up another with a dark stain. As I pushed through the spoon drawer, every one looked old and worn. I dumped them all in the trash. The clatter was delightful.

I'm certain if I read her my poem about how retirement and tossing spoons were alike, she'd laugh, "Riddles again," she'd say. "Anyway, cleaning drawers is not my idea of retirement."

I hear drawers in the kitchen opening and closing. Was she reorganizing my kitchen, as she used to when we cooked dinner together on the spur of the moment?

Before she got her job, she'd call me at work. "Ed's middle name is 'tense' these days. Maybe we'll argue less if we have company. His plane comes in at supper time. I'll bring the sauce. We'll do the spaghetti at your place."

Her meals were masterpieces. Spaghetti became elegant with her secret sauce. She made it seem so easy. Even my disorganized cooking space came to order with her there.

Coming from the kitchen, she taps a wooden spoon on a pan. "Your drawers and cupboards!" she accuses. "Everything's changed."

I swallow my cold tea as Eric drops the bunny and begins to tap the glass jar with the wooden spoon. He hasn't gotten into a rhythm yet.

"Haven't you EVER wanted to break it?" Ann stares fixedly into the bowl, then shows Eric how to pound the pan.

"You wouldn't believe what this child has meant to us. Ed spoils him to death—the son he never had." She raises her voice above the clatter. "He called from California to tell me he's had all his work sent home so he can be there with his grandson. I have to give a speech, and with Ed home, I can run to clean up my own desk work at the office. You know when it piles up ... "

Eric pushes away the pan and taps again at the shell jar, but Ann is still looking at the sand dollar. "Even when you choose to do it, work outside the home is . . . consuming. I can almost understand about Ed, what he goes through—so driven."

She sits back as though the lamp is too bright. "I simply can't save him like I did you. Remember how I called you, to get you away from those awful meetings, how many times I saved you?"

"Saved?" The word echoes inside my head.

She would phone me at work, her breathy voice urgent. "Don't tell them it's a friend, so we can talk." She called when she was redoing the living room, when her daughter went to live with a boyfriend, even the time her roses froze.

"Saved me?" I feel so dense.

"Of course. You remember. You and my girls . . . all needed me. And Ed was away, always away. That's what made it all right, knowing I could rescue you when you needed it. And then the girls grew up. My job came just in the nick of . . . Now I'm not home even when Ed is. Isn't that a switch?"

As a dam inside me breaks, Eric throws the spoon and cries wearily. Ann struggles to put his sweater on him. "We'll have to go home. He's exhausted." She murmurs, as though to herself, "We're both exhausted."

"Wait." I can't seem to get my old teacher voice to work. "Ann, oh, Annie, wait." It seems barely a whisper, but the sudden silence in the room is astonishing. Our eyes meet.

Carefully I lift the sand dollar from the bowl. Stretching it high above Eric, I give it to her. Under the thin shell, the doves wait to fly free.

Tom Joseph

Two Points

A novel excerpt

One – A Whisper and a Wink

This is how it's told in my family. Whether it actually happened this way, I can't say. I wasn't around, wouldn't, in fact, show up for another twenty-five years. I like to think, though, that even back then, I was present in promise, a promise that had carried my newly married grandparents up North to the middle of nowhere, then whispered, "You're home." Who knows, maybe the story's just another of Grampa's bedtime yarns. Would that really matter?

It was May of 1934. Gus and Tess Harriman were on a honeymoon they had no time for and couldn't afford. They'd driven off from Chicago in Grampa's 1929 Packard Roadster with no destination, only a direction. North. Two bone-rattling days later, they found themselves somewhere in far northern Wisconsin at a place appropriately named The Last Resort. After spending the night in a cottage called the Honeymoon Deluxe, which come morning proved identical to all the other empty cabins in every way except for its extra two bucks per night charge, my grandparents stood on the resort's dock, watching the sun rise over a glass-calm lake. A small rowboat was tied up to the pier, and inside the boat were two fishing poles. Grampa hadn't fished since he was a boy in Dubuque, Iowa. Gram never had. But they both looked at the poles with the same attitude that had brought them this far: *Why not?*

Palmer, the resort owner, gave them instructions on row-trolling a sucker and on using a gaff hook. Then he pointed toward an opening across the lake. "That there's the way to Musky Lake. If you don't catch one on the way, find you a cabbage weed bed there. Be careful with your oars. There's so many fish you're like to knock one in the noggin. Bring one back and the missus'll cook it up for supper."

And so my grandparents trolled their sucker through the winding river channel until they reached the next lake. Palmer hadn't exaggerated. There, in a weedy bay between two pine-topped points of land, Grampa caught his first musky—a whopper, over 45 inches, as the story goes. He and Gram downed a couple beers in celebration, then found themselves in need of a place to relieve themselves. The way Grampa put it, as newlyweds they were acquainted enough to sleep in the same bed, but not quite ready to share the same watering hole. So Grampa Gus dropped Grandma Tess off on one point of land and beached the boat on the other.

Grampa always swore the whole idea, if not yet the name, came as he stood irrigating the great white pine. He realized right off it was a preposterous idea. They'd married late. He was over 30, and Tess was 28. They were too old, too busy, and too strapped to consider such tomfoolery. Yet, with the clear northern air, the monstrous fish, the cold beer, and the release of his bladder, not to mention the afterglow from the wedding two days earlier, Grampa was feeling so good that he plain didn't care. There was something special about this place, something that sent all those logical reasons against his sudden plan skimming like skipping stones to the middle of the lake, where they slowed and sank out of sight.

He finished marking his territory, jumped to the giant pine's first branch, and climbed up for a better look-see.

From his viewpoint high in the tree, Grampa could tell that the lay of the terrain was even better than he'd hoped. The two points of land defining the narrow, deep bay were part of a larger peninsula, roughly U-shaped, which jutted into the thousand-acre lake. Somewhere up the shore was the little town that Palmer told them had been named after the lake.

"Gus? Gus Harriman! Darn you, Gus, where are you?" Gram had finished her own business and come tramping through the woods to find him.

"Up here."

"What in the dickens are you doing?"

"You won't believe what I can see from here."

"I don't believe what I can see from here. A grown man up a tree. Who do you think you are, Tom Sawyer?"

"I tell you, Tess. It's like looking at a set of blueprints. It's all there."

"Well, you're not all there, that's for sure. Now get down from that tree this minute. Talk to me with your feet on the ground."

Grampa climbed down and told Gram what he'd seen. The cabin—their home—would go on the high, east-facing slope that promised a view of the sunrise over the lake. The sheltered bay inside the U would provide a perfect harbor for the fleet of boats they'd surely need. On the opposite side of the property looked to be a good sand beach. There, the children could play within earshot, but not so close that they'd interfere with his trolling between the two points. There was plenty of room in between for outbuildings.

"Well, I have to admit, I saw something, too," Gram fessed up. She showed Grampa a long, white-tipped feather. "It's an eagle's. Has to be." She led him to the edge of the lake. "See that big pine on the other point? That's the eagle tree. You can make out the nest from here."

"If the place is good enough for them," said my grandfather, "it's more than good enough for us."

"The fishin's not bad," Gram said, glancing back at the weedy bay.

Grampa glanced, too. Suddenly, up to the surface bobbed all those logical reasons. "We can't afford this," he said.

"It's too far north," Gram agreed. "We drove forever to get here."

"That's two points."

"Two very good points."

They stepped back into the boat and shoved off. Grampa made a few pulls on the oars, then set them down. Gram and Grampa floated in the bay for a long time. Finally, signaling toward the opposite shores with each hand, Grampa broke the silence. "But those, those are two *great* points."

Gram reached up and took his hands in hers. A little breeze had come up. In the wind they heard the whisper.

There's a lot more to the story that, for the most part, Grampa didn't care to talk about. Eventually, though, they built Two Points pretty much to a tee the way he mapped it out that first day.

So that's how it started. As it turned out, Grampa was right about the children part, too. Dad was born nine months and a wink later. A quarter century down the line, Dad passed that wink on to Mom, and I got started, too.

Two – Arrival

It was easy, when I was twelve years old, to mark the day summer began. It had nothing to do with the solstice. I knew that because we'd studied it in science class. The solstice was when you stick a pencil through an orange and walk in a circle around some kid's basketball. Then the teacher tells you to stop and asks the class what they see, and some wise guy says, "Juice dripping on the floor." Finally, someone notices that the pencil is pointing directly at the basketball. That's the school version of the coming of summer. Typical. It has nothing to do with the real world.

Neither did a change in weather announce the new season. Up North at Two Points, it can snow in June. I've seen it. Even in Blaine, Illinois, where we lived during the school year, you might go shirtless in March and need your parka in May. If the thing about the weather were true, we'd have about 158 seasons a year.

The answer was much simpler. Any kid could tell you. Summer began the day school let out.

When, though, was the exact moment? The instant the last bell rang? The second my feet flew off school grounds? Or minutes later, when I got home and jumpshot, hooked and dunked all my spiral notebooks into the bulging trash can as the imaginary crowd chanted, "Two points! Two points!"?

Close. Yet, even those sweet moments were, in truth, no more than the last twitching reflexes of the school year, the kind an animal has after it's already dead, only its nervous system hasn't gotten the message. Summer couldn't really begin while I was still the school-year Danny Harriman, the math brain, the you-play-rightfield ballplayer, the kind of kid who's always in the running for Citizen of the Year. Until something more solid than daydreams came along to crack me open and bust me out of my winter egghead eggshell, summer was still 400 miles away.

As far as I was concerned, the year was divided into two very unequal portions. The first was B.S., the 42-week-long bore Before School let out. The only ten weeks that mattered I called, simply, V. As in Victory. Or as in Vacation. Take your pick. I couldn't wait for the miracle to come along to end the B.S. and transform me into the summer me, free of responsibilities and expectations and homework—heck, just plain free.

How lucky I was to have a miracle I could rely on year after year. It showed up late the afternoon that school got out, as I was dragging the homework-stuffed garbage can down to the curb. There it was, behind my Dad's Olds 88. He towed it slowly past the house, halted, then reversed direction and backed up the driveway. I let out a whoop, dropped the can, and ran alongside. It pulled up in front of our garage. Poof, the school year vanished.

It—*the* it—was the green trailer.

Dad had built the eight-foot utility trailer from two-by-fours and plywood and an axle from Grampa's original 1929 Packard. The trailer was a hefty arrangement, with a drop-in gate too heavy for a skinny twelve-year-old to lift. Its bulk was necessary, though, for it held all our summer needs. Besides the assortment of bulging suitcases, there were our flannel sleeping bags, the Scotch cooler, Mom's box of *Saturday Evening Post* double acrostics (which she brought because newspaper crossword puzzles were too easy), Nick's weight set, Angie's hamster cage, Gram's five-horse outboard, which Dad had rebuilt over the winter, new lawn chairs, a pallet of charcoal briquette bags, a gross of lighter fluid, and a hundred other odds and ends. The trailer held them all, and something more important yet: a promise. It was the very same promise that had brought Gram and

Grampa up North in the first place: Finally we'd be leaving the house in the suburbs and heading for my real home at Two Points.

The trailer was more than the promise. It had survived its winter hibernation outside Dad's office at Harriman Drafting & Blueprinting, and I had survived another winter in Blaine. It was the certain proof that summer had finally come.

From hitch to tailgate, the trailer was painted the same shade as that most beloved of Two Points' buildings which gave the color its name: outhouse green. The truth was, the only finishes that had ever been used on any of the grounds' buildings—and that included the garage, the bunkhouse, the bathhouse where we changed into swimsuits, the boathouse, the screen pagoda and the little playhouse, even my grandparents' house, which had once been a model home at the Chicago World's Fair—were marine spar varnish and that deep, not quite forest shade of green. But outhouse green was what we had always called it, and outhouse green it would always be. Grampa must have had a fifty-gallon drum of that paint. Every summer, one of our chores was to put a fresh coat on whatever needed it.

Merely looking at the trailer took me halfway to Two Points.

Before the tires even rolled to a stop, I was over the side, flashing the V-for-Vacation sign and bouncing on the trailer's floorboards to see how they'd weathered the winter. Naturally, Dad had already seen to that, and greased the bearings and overfilled the tires in anticipation of the heavy load. He was anxious to get going, too. Dad barely pecked Mom's cheek on the way to the basement, where most of our stuff was piled. He didn't bother to take off his tie.

Emerging from the house hoisting two of the heavy suitcases, my brother Nick was ready as well. At sixteen, Nick had muscles and loved to use them, especially when people were watching. He wore his Blaine High gym shorts and his prized University of Moscow sweatshirt with the cut-off sleeves.

Nick looked like the wrestler he was. He had short, thick legs and an oversized torso with arms that hung a foot from his body even when he wasn't carrying anything. He was sure no girl could resist the no-sleeve look, though all it showed off were his tufts of curly brown pit hair. Nick thought like a wrestler, too.

Lifting a suitcase into the trailer, he grunted, "Here you go, Hulk." Nick liked to call me that when I was wearing my own favorite sweatshirt, which showed the Incredible Hulk ripping his clothes to rags simply by flexing. I loved that sweatshirt, half because my muscle-bound hero could snap puny guys such as Nick like string beans, and half because of the Hulk's outhouse green complexion.

With the trailer's arrival and all the excitement, I was feeling the Hulk's power. I hefted the suitcase mightily. It barely budged.

"Shut up," I spat, looking down to see my brother grinning. I avoided his eyes and dragged the suitcase, inch by inch, to the front of the trailer. Sweat beaded on the three hairs under my arms.

I helped tote, wedge, cram and pile until the trailer resembled something out of the Beverly Hillbillies. Dad tied everything down with about a thousand half-hitches, finishing as the sun disappeared behind our neighbor's house. We were ready to head up North.

But we wouldn't. It was part of the routine. We always left in the morning. Tonight Dad would grill a steak, and we'd eat on paper plates. Mom would spend all evening cleaning. "See how I'm leaving the house for you, Isaac," she told my Dad, who commuted back and forth several times a summer. "Try to keep it that way."

Dad knew not to cross her. Though Mom stood barely five feet, she was a coiled spring, wiry and always ready to let loose. Her temper was as dark as her eyes, which when she was mad became little dots of coal compressed so tight they sparkled like diamonds. Dad may have worn the pants in our family, but Mom knew how to snap the belt.

Surprise. We ate steak on paper plates. After dinner I made a last inspection. Rear end nearly scraping the ground, the Olds looked like a sled dog on its haunches, poised for the command to mush. The heck with the load, said the Olds, let's get on with it. I agreed. Why didn't we just leave? I went to bed with the sure knowledge I'd never get to sleep.

The next thing I knew, I was woken from a dream of being attacked by an orangutan, which turned out to be Dad's hairy forearm tickling me awake. He was frisky in the morning and teased everyone, especially Mom, who needed at least three cups of coffee to get going. But even she relented the morning we left for up North, allowing herself to be poured into the passenger side along with her second cup. We bid the house goodbye. I didn't look back. My eyes, the eyes of the summer me, focused North.

Dad drove relaxed, with one hand on the wheel and the other stretched toward Mom. As we approached a red light, he made a show of pressing some button on the dashboard, and the light turned green. We flew through a whole line of stoplights that way, with Dad never slowing down, even though they were red up until the last second. "I know how he does that," singsonged Nick, but when I demanded to know, Nick only sneered and said, "When you're older." Then Dad swung us onto the tollway, throwing the change in the machine as we coasted through. I was sure we'd crash through the striped wooden gate. It lifted in the nick of time.

"Oops," Dad said as we sped up.

"What is it?" asked Mom, totally alert. A second before, she'd been a million miles away in double acrostic land. It's amazing how moms spring to attention when somebody says oops.

"Forgot we were dragging the trailer. We're supposed to go through the manual lanes." Dad checked his mirror for cops. But we were charmed. We were heading up North. No one would dare to stop us.

Dad made sure of that. He carried an empty Clorox bottle in case one of us had to go, which ensured that we didn't, even my six year old sister Angie. We crossed the border in no time. Nick and I leaned over the front seat, straining to be the first to get to Wisconsin, and blew air from one state to the next.

We settled into traveling mode. Dad and I played license plate poker. Nick slept. Mom chewed her pencil and occasionally entered something on her page. Angie fondled her hamsters, Todd the First and Todd the Second, and looked out the window for signs with the only word she could read: E-A-T. When that got boring, she decided to dress one of the Todds in the pink sweater Gram had knit for Wibbly Wobbly Woo, Angie's favorite doll. Angie gave the uncooperative hamster a Mom-style tongue lashing: "Bad boy. You're going to catch your death of cold if you run around without your sweater on. Besides, don't you know how rude you're being? Wibbly gives you her very best sweater, and you won't even try it on? Bad, bad, boy."

We passed a restaurant, and Angie tuned in instantly. "E-A-T. E-A-T. Stop. Oh, please," she pleaded. She should have known by now that we always had lunch at the Blue Sky Supper Club on the Tomorrow River outside Stevens Point. Dad said the place had special memories. Nick agreed. As far as he was concerned, the triple decker club, a sandwich so tall that even my big-mouthed brother could barely get his chops around it, was the world's greatest memory.

Personally, I loved the Blue Sky for another reason—the bathroom wallpaper. It was one restaurant where I never had to be reminded to wash up, which gave me the excuse to take a leisurely look at the walls covered with bra-and tutu-clad monkeys. *I dreamed I was dancing in my Monkeyform bra,* read the caption next to each. Who knew why the monkeys needed the bras? Their chests were as flat as the luckless half of the girls in my sixth grade class who hadn't started developing. But there was something about the lacy white cups I couldn't pry my eyes from, any more than I could when seeing their outline, whether they were needed or not, through a white blouse. I stood and gawked till my hands got red and wrinkly.

Outside of Tomahawk, we passed the first up North lake. Not the farm ponds or shallow, grassy downstate basins, but the real northern McCoy, bog-surrounded, lined with tamaracks and white birches. A pair of loons drifted across the blue water. We'd entered the domain of up North.

It was still another torturous hour from Tomahawk. Neither license plate poker nor car bingo nor a game of ghost could distract me. I watched the odometer creep each tenth of a mile, heard every tick of the dashboard clock. A pool of water seemed to lie on the road surface ahead of us, as if our lake had come out to greet us; but the pool kept moving back, just out of reach. It made me so anxious I nearly had to ask for the Clorox bottle. I thought I'd deceived myself. Summer hadn't begun when the green trailer arrived. It wouldn't start until we got to Two Points. We'd be driving forever. We'd never get there.

Then we went over the bridge between Cross and Pickerel Lakes and passed the Virgin Timber Inn and the airport. Then—finally—we turned. Dad slowed to a crawl. We all opened our windows to smell the freshly-scrubbed air. A blue heron fled from the swamp to our left, scolding us in his hoarse squawk for interrupting his hunt in the shallows. To our right, we caught a glimpse now and again of the lake through the trees and underbrush, which in mid-June still had that just-reborn yellow-green shade of spring.

The road curved to avoid a huge old white pine whose roots were exposed along the eroding hillside. We made a right at the sign carved to look like a cribbage board on which were burned the words "Two Points," then passed between the two giant rocks my cousins and I liked to slide down. They looked smaller this year. We coasted down to the turnaround. We were there.

Ron
Wallace

Quick Bright Things

An excerpt from a novel in progress

He couldn't shake the feeling that they were all going to die. It had come to him unexpectedly, unbidden, as he was preparing his annual lecture on the causes of the Vietnam War, in which he showed how the United States had, with the best intentions, come to the aid of the French in the 1950s, ignorant of the Vietnamese people's history or culture. What was current events for Peterson was ancient history for his students, who had been infants when the war finally ended. He remembered that day vividly, driving home from work to Christine and Jennifer, hearing the announcement on the car radio that the war was officially over. It was as if a weight had been lifted from him. If this war, this endless war, could be over, so could Jennifer's problems, so could his difficulties with Christine.

But it meant nothing to his current students, who seemed more interested in getting the highest grades with the least work so they could get their MBA's and earn the most money. Maybe he could make some connection between the current crisis in the Middle East; maybe he could get them to see how they could all learn something from the lessons of history.

His thoughts drifted to Christine and Jennifer and Phoebe, how much he missed them after only a few days. They had gone to visit Christine's parents in Milwaukee for the long weekend and were due back this evening. Peterson hadn't wanted to go—he had never liked Christine's father—so he pulled out the old excuse of work and drove himself out to their country place. It had been pleasant—the seclusion, the quiet, the freedom to work on his lectures in peace. But this morning he'd woken up with a pain in his chest, indigestion he figured, and all day he had been uneasy, plagued with some inexplicable emptiness or dread.

Halfway into his lecture it hit him: they were all going to die—Christine, Jennifer, Phoebe. He saw them in the Nova, rounding the circle of Goodfellow Road and County Y in the blind spot where the town board had made a gravel cut years ago, Christine, as always, driving too fast, as a pickup truck of high school boys returning from Richland Center slammed into them. The vision played itself over and over in his mind. It was absurd, he knew. But somehow, it was as real as if it had already happened. "So quick bright things come to confusion," he thought, remembering a line from Shakespeare.

He wished now that he had gone with them to Milwaukee. Christine would have preferred that, he knew, and he could have done the little work he *had* to do there. He wished he'd told Christine and the girls he loved them before they left. He *would* tell them when they got back. Jennifer and Phoebe would be returning to college soon, summer vacation over, and he vowed to spend more time with them when they got back from Milwaukee.

If they got back, he found himself thinking again. He wouldn't get any more work done this day, he decided, not with that violent image pulsing before him. Maybe if he walked up to look at the cut, maybe if he ran the four mile circle he hadn't run for years, he could shake off the anxiety that filled him like a canyon of regret. He put down his lecture, found a T-shirt, some shorts, and his old running shoes, and walked up the gravel road to the cut.

The intersection was well-marked, he noted, peaceful and deserted. It seemed impossible that anything could happen there, surrounded by the neatly grazed hillsides, the draws of cottonwoods and boxelders. The corn, after a summer of plentiful rain and record-breaking temperatures, looked lush. At least they hadn't cut *all* the trees, he mused. And some scraggly vegetation now softened the stark limestone walls. The sun was high overhead, and it was almost unbearably hot. It had been over a hundred for three days straight, and it looked like it would be that again today. Perhaps he shouldn't run after all.

He had kept up his running only sporadically over the years; but he remembered now how settling running had been, how the repetitive rhythm of feet on pavement had always helped him think, had given him good ideas. Christine had worried about his heart, his high cholesterol. It was but another of the petty conflicts he wished he hadn't helped perpetuate.

He did some stretching exercises beside the road. He was in pretty good shape, he thought, for a man nearing fifty. Although he could no longer put his palms flat on the pavement, he could touch his toes with his fingertips without straining his legs. "It's because your torso's so long, and your legs are so short," Christine had teased. "Why people value athletic ability so much, I'll never know," she had said.

The wires on the power pole overhead hummed like bees. He started slowly up the narrow black-topped road, pleased at how much better he felt. The first fifty yards were uphill, and he negotiated the crest without getting at all winded. From the top of the ridge he could look out over the countryside across the fresh cut hay and alfalfa, the corn tassels patterning the land like wide-wale corduroy or herringbone, as Christine had once said, to the steeple of the Catholic church—the halfway point on the four-mile circle—and then to the ridges and hills even farther off in the distance. The immensity of the view had always surprised him, the blue sky stretching for miles, the sense of serenity and well-being that unbroken landscape provided. This was why he had bought the property in the first place, away from the city with its crowds, cars, noise, and social demands, its houses jostling each other for attention or looming over the superfluous sidewalks.

As he began the slow coast down the first long hill, he felt a slight pain in his lower back and the hint of a stitch in his left side. He remembered his track coach in high school yelling, "Roll down those hills, Peterson. Roll down them."

He rolled down the hillside past Goff's farm, remembering how Goff had insinuated himself into Peterson's barn, shed, and meadow. "That's a nice pasture you got there," Goff would say. "A guy could put some heifers in that pasture. You gonna put any heifers in that pasture?" Peterson had always felt guilty that he wasn't farming. He didn't want heifers or hay or machinery on his place, but he couldn't think of any good reason to tell Goff *no.* Just saying he didn't *want* them there, that he wanted an empty barn, shed, and pasture, seemed somehow unfriendly. If he wasn't going to use them for their intended purpose, why shouldn't Goff? He always agreed—and then spent days resenting the manipulation. He hadn't talked with Goff at all this season, and he wondered where Goff was keeping his heifers, his extra hay and equipment now?

A tan and white foal grazed beside its mother in Goff's field. Phoebe would like to see that, Peterson thought. Maybe she would see it from the car on the way home later. He imagined her excitedly running to the house to tell him all about it. They had called her "the finder"; she always managed to find things when no one else could—lost keys, money, morels. She was lucky, everyone said. She was always winning raffles, cake walks, coloring contests. She loved animals. Once, after a fight over something, she "ran away" for a day and a night to the tent Peterson had pitched in the woods at the end of their property. She was going to forage for a living, she said. They had just seen *A Midsummer Night's Dream* at a local outdoor theater, and she said she was going to live like Puck or like a deer.

He kicked a piece of baling twine and continued downhill. They had called her "lucky," although she was the one who needed the bottle-thick glasses at age seven—Christine's legacy—and the head gear and braces at ten—Peterson's contribution. She got the nickname "Bean" for her skinny body and stick-like legs. But she was talented, Peterson thought, composing her own pieces on the violin, piano, and trombone. She had even won a city-wide song writing contest.

The hill leveled out, and Peterson noted the yellow, diamond-shaped road sign, with the silhouette of a cow walking into the road, a hole in the cow's ass where some waggish hunter had taken target practice. Cottonwoods and sumac clustered in the draw. The pain in Peterson's lower back sent an occasional pulse down his leg, and his side stitch threatened to move up into his shoulder. "Run through that pain," his coach would have yelled at him. "Goddamn it, just run through it." He jogged on.

If Phoebe had been the Puckish sprite, all angles and energy, Jennifer was the beauty. When she was born the doctors discovered that her head wasn't growing and concluded that she would be a microcephalic. Peterson remembered the strain on him and Christine, how he'd nearly had a breakdown, how they'd gone to Mexico to forget, how they'd mused about a future in which the doctors were wrong and Jennifer turned out not only to be normal, but beautiful and smart. "Not bad for a retarded kid," they'd imagined themselves saying. And then the doctors were wrong, or perhaps Peterson's prayers to the gods were answered. Shortly after the Mexico trip, Jennifer's head started growing, and her development proceeded in textbook fashion from then on. She was living with her friend, Lydia, now and was happier than he had ever seen her.

The road turned uphill again. The sun, aslant over the trees, was already bubbling the asphalt as Peterson watched his feet plod uphill. The front of his T-shirt was drenched with sweat, and his breath was coming hard. He passed the old Thiessen place, where a large dog, chained to a makeshift house, barked at him while dancing to the end of its chain and back. Years ago Peterson had gotten to know all the dogs on the route. He had carried a stick ever since the day Scout, Thiessen's beautiful springer spaniel, had broken free of his chain, scampered down to the road, barking, and made a pass at Peterson, biting him in the calf. It hadn't really hurt—"itched" might have been a better way to describe it. He felt the tickle of hair on his legs as he ran by, saw the flurry of tan and rust at his feet, and felt the itch as the dog retreated to its front stoop.

He had never particularly liked dogs, from the black cocker spaniel his father had brought home for him when he was five—a frantic dog that was always knocking him over in its enthusiasm—to the terrier he had accidentally hit in the jaw with a baseball bat as a teenager when the dog, chasing the pitched tennis ball, leapt up seemingly from nowhere. For years Peterson had carried the memory of that dog—whimpering at his feet, its jaw splintered—trying to persuade himself that it wasn't his fault.

When Thiessen's springer spaniel rushed him, he felt a surge of terror and guilt and kept running until he saw two streams of blood flowing from tooth marks on either side of his calf. He had felt more outrage than anything else. What right had that dog to bite him? He hadn't done anything to it. It was the same kind of outrage he'd felt when that gangly retarded fellow had thrown a cup of cold yogurt in his face as he and Christine were walking home one night when they were first married.

After Scout's bite, the doctor in Richland Center had recommended that Peterson get a tetanus shot and have the dog impounded, but he did neither. Driving to town for the shot seemed too time-consuming, and impounding the dog seemed unneighborly. He suspected that the neighboring farmers already resented his presence in the community—"the rich city guy who bought the old Goodfellow place," he imagined them saying. "No, he don't work none, far as I can see. Teaches at the University or something."

As he passed the Thiessen place, a coon hound came up behind him, crisscrossing the ditch on his right. He wished he'd thought to bring a stick, but the dog didn't seem particularly interested in him and just kept drifting lazily along in parallel, sniffing through the weeds. Peterson reached the crest of the hill and ran more easily along the gentle dips in the road that approached the Catholic church. He looked out over the hillsides, where gray and silver silos glinted in the sun, and black and white Holsteins grazed against the robin's-egg-blue sky. Somewhere over the next hill he could hear the huge ventilation fans roaring in a cow barn and the motor of the vacuum milk tank puttering. Although the pain in his side had abated, the pain down his left leg had become a dull pulse, and both legs were beginning to feel a bit rubbery. Perhaps he would have to walk the last mile or so. He was running straight up and down now, taking inefficient little stutter steps. "Lean into it," his coach would have insisted. "Stretch out."

He took several deep long breaths, the smell of silage and manure assailing him. Several Holsteins looked up, half-interested as he passed, and one calf followed him from inside the electric fence on his left for a few dozen steps.

He could see the steeple clock on the Catholic church clearly now, its hands stuck at twelve. He must be moving slowly today, he thought. In the old days it was fifteen minutes exactly to the church. Today, by the church clock, it had taken two hours. At this point in the circle he had inevitably thought about his father. Just when Peterson felt like walking—wondering what he was doing out in the hot sun, his T-shirt and shorts drenched with sweat, his legs weak, his side aching, his head pounding—he'd thought about his father slumped over in his wheelchair in the nursing home, his gold front tooth gleaming through the crack in his half-smile. His father couldn't lift his head or move more than a finger and would have given anything to be able to run as Peterson was. For a man who could no longer feel anything, the side stitch, the rubbery legs, the sweat, the shortness of breath would have been an indescribable pleasure. Peterson's petty fatigue was nothing compared to his father's incapacity, and this thought spurred him on. At any moment, you could be paralyzed or dead. He quickened his pace, the adrenaline flowing almost as it had when he was eighteen, running cross-country in high school, his mother urging him on at the finish line with the coaches and other fathers, where his father should have been.

He topped the hill by the church, its stone serenity unchanged. His mother was still active in her church, Peterson mused. Eddie had turned out to be a godsend for her after Peterson's father died. They still traveled to Florida or Hawaii every winter and Canada or Minnesota every summer. Peterson wished he had been more accepting of Eddie. Peterson's hostility had distressed his mother unnecessarily, and it certainly hadn't done his dead father any good for Peterson to remain morally outraged by his mother's affair and hasty remarriage.

It might have made a good story, he supposed. Peterson's father had wanted to be a writer. But the only things he had ever written, as far as Peterson knew, were a short sociological study of Peterson's mother, for a college intro class, and a "How I Live with a Disability" piece for *Reader's Digest.* His sociology thesis—that his wife's rigid moral upbringing at the hands of her father, a Lutheran minister, was counter-productive—seemed to have been borne out in her sister Ida's alcoholism, her sister Martha's escapades with a variety of men, her brother Wilford's sexism, and her own affair during her husband's illness and her hasty remarriage after his death. Or maybe it was just his grandfather's moralistic genes that had determined Peterson's overreaction to his relatives' difficult lives.

The *Reader's Digest* piece was thin and cliche-ridden but sincere. Peterson's father had responded to a call in *Reader's Digest* for first-person stories. They offered $1,000, but it wasn't money or fame that interested him. He believed that his account of his experience with multiple sclerosis could help others. The article was never published but remained a yellowing typescript neatly folded in his father's metal strongbox where Peterson found it after his death.

A rustling in the grass at the side of the road brought him back. He glanced into the weeds, but his eyes were bleared with sweat, and he could see nothing. Years ago, he had fancied that such rustlings were snakes. They were probably no more snakes than was the piece of rope with which his uncle Wilford had scared off the women at the family reunion. Wilford had died not long ago, Peterson had heard, in his fishing boat, adrift on a farmer's pond. His wife, Evelyn, had gone out looking for him late one evening when he didn't come home. She found him in the moonlight, his pole still in his hands, his line run all the way out as if he had finally hooked into something big. She had waded out to the boat, cut the line, and sat with him all night before calling the coroner to come and take him home. Now she lived with Peterson's aunt Martha, who had finally given up on men.

Peterson fought up the steep incline to the old Hubble place, with its shabby asphalt siding, its rusted tin roof, its unmown weedy farmyard—all quack and burdock—its defunct gray windmill, its pile of trash. He had always been appalled at the way some of the farmers just dumped their trash into ditches and draws on their property or piled it in the yard. But what were they supposed to do with it, he asked himself. He had always taken his trash surreptitiously to town and found a dumpster.

He remembered how the Hubble's dog, Spike, had always chased after him for fifty yards or so, barking menacingly. Now, as he turned the sharp corner and began the long downhill before the last uphill section, he caught sight of another dog, much like Spike, bounding from behind an outbuilding. It was a mongrel, its black hair mangy and burr-ridden, the dirty scruff around its mouth shaggy and wet with saliva. It snapped at Peterson's legs and bottom, snarling, but then fell into place off to his side in front of the more docile brown coon hound that had been accompanying Peterson. He supposed if they were planning to bite him, they would have done so by now, and he relaxed into a smoother downhill pace.

If the mongrel looked a lot like Spike, the coon hound was a dead ringer for one the children had brought home years ago. "It just followed us, Dad," they had said. "And I suppose you didn't encourage it?" he had replied. "No," they'd insisted. "Did you discourage it?" "Well, no," they admitted. Peterson had explained, somewhat abruptly, that the dog probably belonged to someone else, that they would be sorry to lose it. "You wouldn't want that?" he asked them. "No." They lowered their heads. Although it was getting dark, he'd insisted that they walk the dog back to the house where it had joined them. When they hadn't returned after an hour, he drove off after them, half angry, half worried that something had happened. When he found them on the road, with the dog at their feet, they'd explained that no one was home, and every time they tried to leave, the dog followed them. Phoebe was in tears. "We knew you'd get mad," she said, "if we brought the dog home *again.*"

The pain had become fairly constant in Peterson's left side now, and he was running, even downhill, with a slight limp. He would stop soon and walk, he told himself, taking several deep breaths. A strong smell assailed him, alfalfa and cows, yes, but some other smell he hadn't experienced for some time, a sweet but rank smell, a musky, slightly sour, overpowering odor, the odor, he realized, of something dead. The coon hound wandered off in the weeds to investigate. These were the August days, Peterson recalled, when families of raccoons and possums chose to cross the roads. Phoebe, he remembered, was horrified by the deaths of animals. People never affected her quite as much, but an animal, dead on the road or in a book or a movie, could make her weep inconsolably. When she'd see something in the road from the car, he'd assure her that it was just trash, a paper bag, something that had dropped from a farmer's truck.

Three crows rose flapping from the weeds as the coon hound continued circling. Peterson remembered a conversation he had had with Jennifer. Out of the blue one day she'd said, "You know, it's a good thing people die."

"Why is that?" Peterson had asked.

"It gives you a reason to do things. If you were going to live forever, why would you do anything?"

"If you're just going to die anyway," Peterson had baited her, "why bother?"

"Everybody has something to accomplish. Some contribution, some things you need to do. Death gives them some *urgency.*"

Not a bad little philosopher, Peterson had told Christine later. Not bad for a retarded kid.

He was running on the valley floor now, through bottomland, flat and even. Some of the pain had gone, and he could see the shade ahead where the long final hill began. Maybe he could run the whole way after all, he thought. He coasted along the road. *Everybody has some thing to accomplish. Some contribution.* What had been his contribution? The past few years seemed a blur of sameness—the history courses that he knew by heart, the yellowing lectures he swore as a young professor he'd never resort to, the gradual withdrawal from departmental affairs as younger colleagues implemented changes in committee organization and degree programs, the migration of his friends to better paying positions at more prestigious universities, the failure to finish the books he had once hoped would make his reputation.

Oh, there had been some high points—the first few years of teaching, the publication of a few dozen articles and poems, the citation for excellence in service to the College. But the older he got, the less interested he was in his career.

And then, of course, there was Lissa . . . .

He passed into the shade at the bottom of the long hill. It was the first shade he'd encountered on the run, and it eased him somewhat. The hillside was in shadow, the sun having dropped behind the steep, treed bluff. It was cooler in the shade, and he welcomed it, although the hill would be difficult and long. Staring at the pavement now, pushing himself to get up the long last hill, he heard the chirr of crickets and locusts and saw the cabbage butterflies laying their eggs in the cracked asphalt at his feet.

The white indentation of a tooth mark was still visible on the inside of his calf as he forced his legs up the hill. He remembered his outrage years ago as Scout scampered back to the porch yapping. It had taken old man Thiessen a few minutes to notice Peterson out front shouting and pointing. Peterson wasn't about to leave without letting Thiessen know what had happened, but he couldn't approach the house with Scout stationed in the way. When Thiessen finally saw him, he insisted that Peterson come in, have the wound treated, and have some breakfast. Thiessen was seventy and hard of hearing. He apologized to Peterson as he shakily applied some merthiolate and tried unsuccessfully to get a bandaid to stick to Peterson's sweaty leg until Peterson finally dissuaded him. Peterson had ended up staying so long to talk that Christine began to worry and came looking. "I thought you'd had a heart attack for sure," she told him later.

He still had two scars from that bite. He remembered a storyteller who had visited his fourth grade class—was it nearly forty years ago?—and told stories about some of his scars. The storyteller then had the children tell stories about their scars. When it got to Peterson, he had no scars to tell about. After school, he'd run home to his mother feeling embarrassed and deprived. "Don't worry," she'd told him. "You'll have your scars to tell about soon enough."

He passed a road sign that had always amused him—steep, winding curve, 15 mph—and joked aloud that he guessed he'd have to speed up. He was running so slowly now that it was more like a walk, a slow motion pantomime of running, as if the pavement were moving steadily away from him with each step, his feet barely able to lift themselves under his body to keep it from falling. He was almost back to the house now, just half of the long hill to go. He thought of Jennifer and Phoebe playing badminton, Christine humming at her loom, the goats clattering on the oak platform he'd built for them in the pen he'd constructed out of old gates he'd found around the farm, the chickens poking through the new mown grass for insects and scraps. He thought he could hear a dove cooing in the boxelders, a phoebe calling its name from a fencepost, a bevy of goldfinches ringing their tiny bells high on the wires.

The cool breeze in the ridge's shadow chilled him, a shiver that started at the nape of his neck, where his wet hair dripped, and trickled down his spine, wrapping itself in tiny rivulets around his ribs and chest. And then the rivulets were thin arms squeezing gently, pushing him toward the unmowed roadside weeds, his legs and thighs trembling with the unending incline, as he thought *yes, a rest wouldn't be such a bad idea, yes, just a few moments in the weeds, yes,* as he stumbled into the Queen Anne's lace and chicory, the ragweed and wild mustard, the goldenrod and coneflower, and collapsed, dizzy, wheezing. It was peaceful in the weeds, a few bees humming, three dogs circling, a cardinal red in the trees.

He remembered stories of Goff's wild dogs roaming the woods, attacking deer and cattle. He had heard their ghostly yelping across the hills on starry evenings, the full moon illuminating the farmyard with milky light. Now the mongrel that had followed him loomed lean and ominous, teeth bared, mangy face thrust in his face. "Spike," he heard himself say. "Spike." Now Spike was licking his cold forehead and cheeks, the dog's rough tongue soothing as a massage. Now the brown coon hound had joined him, and other dogs gathered around, cooing and warbling.

Christine would find him. She'd arrive home to an empty house, begin to worry, and bring the car around. She'd chastise him for pushing himself too hard. "What a foolish thing to do," she'd say. Off through the fillips of Queen Anne's lace and chicory, he thought he could hear Phoebe and Jennifer singing in the breeze. And was that Christine singing, too? They had always made such wonderful spontaneous harmony. *So quick bright things,* he thought. *So quick bright things.* Now all the dogs in the neighborhood were gathered, like Theseus' musical hounds, yipping, yapping, and yodeling in unison some familiar tune. Now a howl, now a croon, now a moan. Now the Queen Anne's lace and chicory. Now the wind without measure or sound.

Saint Philomena, Pray for Us

Gordon Weaver

Yea, though I walk through the valley of the shadow of death . . .
Psalm 23

More than forty years ago, the sudden death of Kevin O'Leary, my student, made me remember Saint Philomena, patron of dentists. When I was sixteen, my mother remembered I had not seen a dentist since I lost some baby teeth. "Why should I go to a dentist?" I said. "I brush."

"I have an appointment for you at Marquette," she said.

"Marquette? The college?"

"The university dental clinic. You get your work done by dental students."

"Why can't I go to a regular dentist? We're not Catholics."

"And we're also not made of money," my mother said.

So I began a regimen of treatment—prophylaxis, x-rays, a dozen serious cavities drilled and filled, one difficult extraction, two gold crowns—lasting nearly a year, a cycle of boredom and pain, the whole of it marked in my memory by the image of Saint Philomena. I think of it now as a year spent in exile, my innocent, unruly, resistant self banished intermittently to dwell among hostile and exotic aliens: the Jesuits who walked the campus in their black suits and dog collars; the dental students and instructors in white smocks—instructors identified by a red shoulder tab; the motley community of destitute and semi-destitute patients I joined.

But mostly during these periodic exiles I lived in the casual torture of pick, chisel, drill, extractor, with only the brief respite of only occasional novocaine.

I ascended a staircase to the waiting room, past the mural-size portrait of

Saint Philomena on the landing, checked in at a window like a bank teller's, showed my card, took a seat on one of the long wooden benches, as inhospitable as a church pew. I avoided all eye contact. We were a shabby crew of unfortunates: Negroes, harried mothers and their crying or screeching children, thin, unshaven men, clearly skid row winos.

Name called by a bored clerk, I rose and entered the clinic, a hall the size of a basketball court, with row on row of dental chairs, the whirr and whine and buzz of a hundred drills, a pervasive smell, vaguely medicinal, faintly metallic, white smocks everywhere, walking briskly, bent over patients, gathered at the counter where materials were dispensed.

I found my assigned chair—two rows in, seven down—and greeted my assigned student. "Hi," I said, or, "Hey," or, "How you doing?" He never spoke to me; I suspect he did not like juveniles and wonder if he liked anybody. The plastic badge over his smock breast pocket said *Styron*. He nodded, gestured me into his chair, and, after a cursory look at my x-rays and chart, set to his work, the infliction of pain.

The pain—*pain!*—has dissolved over time into an amorphous cloud over my otherwise quotidian teenagehood, one instance almost inseparable from another. The probing of Styron's needle-pointed pick, releasing mouthsful of warm, sweetish blood on my tongue, elides into the burn of the slow-speed drill he seldom lifted to allow it to cool, merges with the explosive jolt of nerve response stiffening my spine, rendering my muscles rigid, freezing the grip of my fingers on the chair's armrests, melds with the crack and crunch of his chisel deep in the shell of a tooth, transmogrifies into my throat's spasms as I gagged on my saliva, is absorbed into the shock of chill water rinse bestowed without warning, the flood of cold air Styron squeezed from a rubber bulb to clear his view.

Perhaps the most intense pain was the sensitivity test. "We need a sensitivity test on that before you bother with an amalgam," the red-tabbed instructor told Styron. Styron wet a paper napkin, wrapped it around a metal baton, and handed it to me to hold. From the baton, a thin cord ran to a black box with a dial set in its face. From the box ran another cord, ending in a wire he placed at the bottom of the cavity he had just drilled. He flipped a switch, the current ran through my nerve, and I jerked in my chair like an executed criminal. The tooth was live, could be saved

Instructors inspected each stage of the work during these two and three-hour sessions. Styron went to get mercury and silver to blend fillings, returning with a receipt for my mother's money. His rare breaks were occasions for speaking to me. "I got to step out a sec," he'd say. When he returned, his breath was rank with his just-finished cigarette.

He talked to his friend and fellow student working the next chair. (I never learned his name.) "So how many inlays you done now?" Styron might ask him. Five, or ten, or a dozen, his friend might reply. "Just shows what a fucking prick you are," Styron would say, or, "You must be as lucky as you're ugly, huh?" or, "Beats the living shit out of me." They spoke of their various instructors, Styron calling them pricks, turds, bastards, sons of bitches, ass-faces.

This year's regimen of pain, I am convinced, left me the physical coward I have been the rest of my life.

The day's appointment done, I walked out of the clinic, through the waiting room, always near-full with the destitute and near-destitute, all awaiting their pain and boredom, down the flight of stairs, past the portrait of Saint Philomena.

She was depicted in full color, on her knees, hands folded in prayer, a yellow halo like a dinner plate surrounding her head. Her large eyes turned upward in ecstatic search of the deliverance she presumably never doubted. Her bloody mouth, lips collapsed inward, was stark against her dead-white skin. Arrayed about her on the ground were all of her teeth, torn from her jaws with pincers wielded by Moors before they martyred her by fire. This was in north Africa, in the fifth century A.D.

As I came up those stairs to my appointment with Styron, this picture terrified me with its promise of torment, but, descending, I could confront her with something like smugness. I had not died, nor was I likely to—at least not under Styron's indifferently harsh hand.

My family was nominally Protestant, most tenuously Lutheran. Approaching Christmas, my mother topped our tree with an angel and arrayed a hand-painted creche at its base among the wrapped gifts. On Christmas Eve, she took me to midnight services.

"Do I have to?" I complained.

"It won't hurt you," she said, "and it might even do you some good."

I asked my father, also compelled to go, if he believed in religion.

"It's all right to believe so long as you don't get all fanatic about it," he said. He wore a Masonic ring, but I never knew him to attend any lodge. He loved to laugh at Oral Roberts, then a Pentecostal working out of tents in Oklahoma, who called on viewers to place their hands on their television sets to receive his healing. "Get a load of this!" he would shout. I laughed with him. My mother tried to smile. I once watched my father behave with great rudeness to a Jehovah's Witness who came to our door with her small son, offering *Awake!* and *The Watchtower* for only a quarter.

When my mother insisted I enroll in a confirmation class, I appealed to him. He shook his head in sympathetic disgust and said, "Grin and bear it if it makes her happy, okay?" An icy-dour pastor with rimless spectacles conducted the class, requiring us to memorize impossibly numerous scriptures quoted in Luther's small catechism. When I dropped out, my father stood with me against my mother's disappointed anger. "She'll get over it," he advised me.

When I once asked him to explain Freemasonry to me, he told me about

Hiram Abiff and the building of the temple. "It's sort of like a religion," he said. "You follow it, and it kind of takes the place of a religion. You can make a lot of contacts."

Whenever I brought my mother to the edge of her patience and to the verge of tears, she exclaimed, "Jesus H. Wept!"

When my father died, I was surprised to find he had asked in his will for a Masonic funeral. I remember the strangers wearing their stylized carpentry aprons while presiding at the ceremony but cannot recall anything they said.

When my mother died, a Lutheran minister who never met her delivered a eulogy derived from things I told him of her life.

I have not set foot inside any church for nearly half a century. I have only recently begun to think so often about Saint Philomena.

After being educated at tax-supported institutions of higher learning, I was hired to teach at Saint Bernardine College, run by Franciscan friars. I was only mildly apprehensive. The dean who offered me the position, Father Brian, sprawled in his swivel chair. I remember feeling a momentary fear he might expose a thigh or worse as he shifted, crossing and uncrossing his bare legs and adjusting his robe, the beads at his waist clicking. He did ask if I feared being proselytized and assured me nothing of the sort would happen—the truth, for nothing of the sort did. I told him I had no such fear, no feeling one way or the other concerning his religion; I lied.

I enjoyed teaching at Saint Bernardine's. My students, all male, mostly of Irish, Italian, and Polish descent, ninety-seven percent Catholic, were eager, diligent, and docile, dedicated to their education as a certain vehicle upward from their blue-collar origins. I exulted in the breaks their mandatory retreats and feast days gave me.

My first class informed me it was customary to begin and end each session with prayer. I told them, I hope without sneering, that, while I could not, would not participate, I would appoint a class chaplain to conduct the exercise while I stood by, looking out the window at the manifest of each season expressed in the beautiful campus grounds.

I soon grew used to the crucifix in each classroom and learned to ignore the initials they jotted in the corners of writing assignments submitted to me—JMJ, for Jesus, Mary, and Joseph. The opening and closing prayers became a kind of bracket to each meeting. "Saint Francis," my designated chaplain would lead, or "Saint Dismas," or "Saint Bernardine"—the choice was the student chaplain's—"pray for us, now and at the hour of our deaths," they chorused before the amen and genuflection.

I admired some of my Franciscan colleagues. Father Capistran pursued serious secular philosophy and had a bishop's dispensation to read books on the Index.

I disliked others. Having taken his doctorate from Franco's Madrid, Father Amadeus was a rabid anti-Communist and organizer of the Cardinal Mindzenty Club chapter. Father Giles had been Goering's confessor at Nurenberg. Father Cyprian confessed John F. Kennedy aboard PT-109. Father Peter confessed the wife of the state governor's director of taxation and so could retail reliable insider political gossip.

Several of my colleagues, I later learned, reverted to their given names, a few resigned their vocations, and at least one married in the aftermath of John XXIII's Vatican II.

In my third and final year on the faculty of Saint Bernardine College, I appointed Kevin O'Leary chaplain of one of my freshman composition classes.

What can I trace to my childhood? Bits and pieces:

My friend Ronnie Makowski's parents invited me to eat supper with them. In their dining room hung a cheap depiction of the Sacred Heart. His parents talked, Ronnie talked, I ate my meat loaf and mashed potatoes in silence, fascinated by the garish reds and golds, the heavy metal frame above Mr. Makowski's head. Sometime after Palm Sunday, a yellowing frond was tucked behind the frame to stiffen and wither. I of course did not dare ask what all this was, what it might mean. Asked perfunctory questions, I replied politely, as I had been taught by my parents. To question another's religion, I understood, was as rude as staring at a blind man and his dog or at a cripple's limp or crutches.

We—my nominally Protestant friends and I—called Catholics *mackerel snappers* for the fish they ate on Fridays. Ash Wednesdays, they came to school with smeared foreheads they were forbidden to wash. Questioned, they joked, said they were angels with dirty faces.

Swimming at our neighborhood's municipal pool with my friend Ronnie Makowski, I saw the scapular he wore on a thick string around his neck. When we played basketball, Ronnie crossed himself before shooting free throws. This was fashionable for some years but long ago disappeared from the game.

When the husband of our seventh grade teacher, Mrs. Lillian Leet, died suddenly, Ronnie Makowski brought her a prayer card when she returned to our classroom after the funeral and a short period of mourning.

On his birthday, Ronnie Makowski treated me to a movie matinee; I do not remember what movie we saw. He reached in his pocket for his money, withdrew it; his rosary caught on his fingers and clattered to the pavement in front of the ticket window. He picked it up, rolled it into a ball, stuffed it back in his pocket. Instead of asking him what it was, I thanked him again for treating me to the movie.

These bits and pieces come from scattered days, all before I saw the portrait of Saint Philomena.

Ronnie Makowski became a first-rate athlete. Marquette University gave him a football scholarship. Preparing for his first varsity season, he worked out in the university gym. He was doing situps, I read in the *Journal* sports section, when he suffered a heart attack. He was found dead, stretched out on his back on the floormat. The person who found him, the newspaper reported, thought at first he was asleep.

This happened three years after my dental work was complete, when Ronnie and I were no longer friends, when I had forgotten all about Saint Philomena and the pain inflicted by the student named Styron.

What is more contemptible than contemporary religion?

My father hooted at a sweaty Oral Roberts, then a Pentecostal holding revivals in circus tents, claiming to heal through television sets. Roberts turned Methodist for respectability, and I watched him emcee slick variety specials complete with Hollywood guest stars, hair-sprayed, attired in designer suits, claiming to have spoken to a giant apparition of Jesus. I could not transcend my disgust to laughter.

Cable channels bring us smarmy frauds—Bakker, Swaggert, the Crystal Cathedral, a host of blatant swindlers and pitchmen and women—ad nauseam. On prime time, the networks coddle the likes of Billy Graham, Jerry Falwell, and the reactionary pope from Poland.

What could be more contemptible?

I find some solace in their inevitable humiliations. Their sham universities and theme parks declare bankruptcy, they are compromised in sleazy motels, they are strangled in lawsuits. Or they simply fade, are forgotten, like aged rock musicians. Who remembers Bishop Sheen? Who mourns Ezra Taft Benson?

Ichabod! Jeremiah would cry—if there were a Jeremiah among us today. The Glory hath departed us.

And beneath contempt, unworthy of laughter, are the faceless ranks of the mock-pious, the dressed-in-Sunday-best crowding fast food restaurants and sports bars after services scheduled to conclude in time for lunch. Drunkard's Mass, I heard my boyhood friend Ronnie Makowski call the late worship permitting Saturday's revelers to sleep off their hangovers.

Oh yes, there are those who feed the starving, shelter the battered, comfort the despised, march shoulder to shoulder with the outraged dispossessed. But this is politics, of no interest to me.

In the end, there is precious little to laugh at, scarce sufficient cause for righteous anger.

Kevin O Leary.

Kevin O Leary, class chaplain, led the prayer to open the semester's last meeting before final exam week.

I did not think it was a good class. I was ready for the semester to end, anticipating summer, and so struggled, I think, to be enthusiastic, to inspire my students to enthusiasm. And they, too, were tired of the semester and anticipated the coming summer. I do not remember why we should have been discussing poetry at this last class meeting. The poet was Emily Dickinson, the poem her "Because I could not stop for Death." My students sat, lethargic, indifferent, bored as I all but shouted the lines at them. I do not know why I should have cared so much to generate some response to this poem. There were only a few minutes left when I snapped my text shut and scolded them.

"You think this has nothing to do with you," I said. "You think this is some quirky old maid nattering away at you, and you couldn't care less, right? Well, she's talking to you, and you should listen. You hear what she's saying? She's telling you Death is coming for all of us, and you can't stop it, and you don't know when it's coming, or how it's coming, but it's coming. Not you, though, right? All you can think about is summer vacation, getting out of here, going home, what you're going to be doing tomorrow and the next day, this summer. You're all bound up in your own little lives, aren't you!"

My students did me the courtesy of pretending attention; I understood very clearly I was having no effect at all.

"You just assume," I told them, "you'll wake up every morning, the way you assume the sun's coming up, right? So you care less about Miss Emily's little poem here, right? Well," I said, "you shouldn't." And when there was no flicker of response to this, I looked at my watch, saw we were only a minute from the bell, and said, "Shut us down one last time, Kevin."

Kevin O'Leary stood and led the closing prayer while I stared out the window at the greening, blossoming late spring of Saint Bernardine's campus. I was tired, momentarily disappointed in my students and myself, glad the semester was over.

Which saint did Kevin O'Leary call upon to be with him and his classmates, then and at the hour of their deaths? I cannot recall.

They come to me in a rush, a torrent, an illogical, incoherent flow:

Scapulars and prayer cards, rosaries and ashes smeared on foreheads; bleeding hearts and crucifixes and holy candles and holy water, counterfeit relics; the eyes of statues weep; the hands and feet of celebrated priests and nuns ooze blood at Easter and Christmas; trees and windows and clouds and even vegetable roots exhibit the likeness of Jesus or Mary; plastic Christophers mounted on dashboards; love offerings shamelessly hawked in exchange for tithes; Reverend Ike's prayer cloths guarantee prosperity; crosses worn in the ears, dangled in cleavages; incense and gongs, Buddhas in all sizes; Muslims unroll their rugs in response to prayer calls broadcast from skyscraper minarets; the earlocks of skull-capped Jews flop to and fro as they rock in prayer against the wall; aboriginals gather at their totemic bamboo control towers and miniature airstrips to coax airplanes out of the sky; Mexican penitents crawl their knees bloody, scourge their backs with thorns; Shinto monks clap hands to summon the spirits of their ancestors; stone ruins of Aztec sacrificial alters; Indians chew peyote; naked Dukhobors assemble to watch their homes burn; snake-handlers and strychnine drinkers; speakers in tongues and recipients of Inner Light epiphanies; bearded Amish in their buggies; Mennonites rebuild houses destroyed by acts of God; hex signs on barns; hot cross buns baked on Good Friday; Nostradamus's riddles; Masonic aprons; horoscopes and polished lucky stones, rabbits feet and horseshoes . . . .

I once drank wonderful coffee, fresh-ground in the refactory, with the faculty of a small Benedictine college in Louisiana; the view from the picture window was the cemetery where they would all eventually join the brothers gone before them.

Saint Philomena.

Late on the night of the first day of final exam week at Saint Bernardine College, Kevin O Leary, having spent all day and evening cramming, left his dormitory alone and walked off campus to the state highway. He walked down the highway toward a convenience store, open twenty four hours, to buy—what? A soft drink? Snack food? Cigarettes? He wore a dark T-shirt, dark slacks, sandals. He walked on the right-hand side of the pavement, just on the gravel road shoulder.

What might he have been thinking about as he walked? I can only imagine. He might have thought how balmy the night air felt. If he looked up, he saw no stars, for they were masked by cloud cover. He may have thought about what he went to buy—soda, snacks, cigarettes? Perhaps he thought about his final examinations, maybe even of questions about poetry he knew he would find on my final examination.

Nothing is certain. He may have been humming, singing, talking to himself, may have walked, hands in pockets, jingling coins, may have strode, arms swinging, or strolled, even shuffled lazily. Pure speculation.

If he hummed or sang or spoke, he possibly did not hear the automobile that struck him, killed him instantly, from behind. Did he not see its headlight beams cast on the pavement and gravel ahead of him? Did he walk with his head down, lost in thought? Could his eyes have been closed just in that instant? Why did he walk so close to the road?

Kevin O'Leary was struck, killed, thrown into the deep ditch running alongside the state highway; he was hit so hard, his feet flew from his loose sandals, found on the shoulder, marking his last steps.

That is all. There was of course a somber memorial gathering on the campus of Saint Bernardine College, but final examinations were held on schedule. We opened my class's exam with the usual prayer, and an extra prayer for the repose of the soul of Kevin O'Leary; for this I appointed a new class chaplain, because, of course, I could not lead any prayer, could not pray. That is all.

Kevin O'Leary. Ronnie Makowski. My mother and father. The priests and ex-priests of Saint Bernardine College. The Benedictine brothers of that small Louisiana college. Styron. I believe I could compose a very long list. If there were ever to be such a list, I wonder who would add my name to it? That is a vain, foolish thought!

What I truly wonder—and it is not foolish or vain!—is if there will be anything I can hold in my hand, or any words I can speak, any name I can call out to, when my hour is upon me.

David
Tabachnick

Fatimata's Ancestors

Sekou Traoré, chief justice of the Supreme Court, came from a family of craftspeople. The Traoré family specialized in wood and ivory sculptures, and throughout Conakry, roadside vendors stacked their sculptures on unsteady tables or set them out in orderly rows on indigo cloths.

Lamine Traoré was the chief designer at the family workshop. He invented a line of figures that were all knees and elbows and featureless faces cocked attentively. He said that these figures represented contemporary Guineans—hollow men bereft of any commitment to the national community. His workshop produced immaculate re-creations of Baga ritual statues, one of them a three-foot long birdlike head with human eyes. The Baga had been famous for their art and ceremonies in the French colonial era, but the post-colonial dictator, now dead, had prohibited the Baga from practicing their art and religion.

Lately Lamine had used some of Picasso's ideas in his work, delighted that a man so influenced by African designs should in turn inspire an artist in Conakry. "I need a room of my own and an open window," Lamine would say.

Sekou Traoré, like his brothers, could carve wood, but he chose law over the family business. As a child he was permitted to go to school but required to practice his woodcarving. He hadn't carved anything for years but still woke sometimes with a block of wood in his hands, convinced that his father was up and waiting to see what he had done. He became a professor of law in Senegal and then moved back to Guinea after the death of the old dictator.

The case before him had been in the courts for twenty years. Sekou Traoré had written out his ruling by hand and read it from the bench to the lawyers and parties seated in the court. Some judges tease you with their ruling, swaying the listener first one way, then the other, blasting at one side and raising the hopes of the other, only to slip quietly into reverse and rule in favor of the side so beaten and discouraged. Sekou's ruling started with the punch line.

"This court finds in favor of the appellees and upholds the rulings of the lower courts that have uniformly rejected the specious arguments of the appellants for the past twenty years."

Sekou Traoré paused and stole a glance at the audience. Murmurs rippled. An elderly man sat erect, tears on his cheeks, young men on either side whispering and exchanging glances.

"Twenty years ago," he continued, "the Diallo family, in a fit of greed, ordered the Bah family off the land the two families had worked side by side for over a hundred and fifty years. In former times, the Bah family served the Diallos as their slaves. We are all aware that even today people of the Guinea highlands, where this dispute occurred, still identify themselves in terms of their social caste: noble or ex-slave. Nonetheless, such social castes have no legal basis in modern Guinea. All Guineans, ex-slaves and nobles, men and women, are equal before the law.

"In modern Guinea we have one law, the modern law of respect for all individuals and for the rights of the individual to private property. The Diallos argue that as nobles, they own the land worked by the Bah family and can dispose of the land as they wish. The Diallos argue, in effect, that they own the land because of their rights as nobles who conquered and enslaved the Bahs, and that as noble owners they have no obligations to the Bahs but may dispossess them at will. The Diallos are wrong on both counts.

"Where do these ownership rights claimed by the Diallos come from? Nobles never, even in ancient times, had the right to expel slaves at will from the land they cultivated. Even in the days of slavery, slaves who fulfilled their obligations to noble families had the right to continued occupation of the land. The Diallos' ancient rights did not include an absolute right to expel the Bahs. The state of Guinea, in adopting the modern law of individual private property, has not added to the rights of the Diallos and subtracted from the rights of the Bahs. Neither have the Diallos added to their rights by paying the Bah family for the right to expel them at will. Clearly the Diallos do not own such a right.

"In any case, the old regime of nobles is gone for good. For decades the Bahs have worked peacefully and productively beside the Diallo family on the land in dispute. It is in both the national interest and the interest of the local community that those who work the land benefit from their labor and be able to live in peace and security with their neighbors. Over these many years, both families have acquired property rights in the land at issue. The equitable solution, therefore, is to divide the land between the Diallos and the Bahs.

"The court orders the Governor of the Labé region to mark out a division of the land forthwith so that the land may be planted with its first crop in twenty years."

Sekou Traoré vanished in a swirl of judicial robes.

"Eh, I gave it to them straight, Madame Camara," Sekou said as he hung his robes in a closet. He came out of his office into the anteroom where she presided over a manual typewriter.

"People can sort out their problems according to the old rules or come to court and taste modern law," he said. "We have been held back too long. It's time to do business!"

Outside the court the old man, still surrounded by young men, his tears dried, shook hands with well wishers. Supporters of the losing side pushed by, all hard shoulders and dark looks. From out of this clot of men in suits there emerged another erect old man, dressed in sky-blue robes threaded with gold. He paused before his counterpart, more plainly dressed in a brown suit. He hitched his robes over his left shoulder.

"Yacine, you are looking well. We don't see much of each other, since this trouble began. Now we are finished with courts." He suddenly held out a purple nut in a gold brown hand. Yacine spoke, and one of the young men beside him took the nut and threw it away. The elderly man hitched his robes and smiled. "You still fear me. That is good. You know that slaves do not own land." He walked on, and the two groups parted, gloom settling over both.

Conakry is a gloomy city, most of the buildings made of whitewashed mud speckled with patches of brown where the whitewash has worn off. The wet heat softens the mud. Sometimes a little green wriggles up in the courtyards of closepacked houses.

The morning after Sekou Traoré handed down the court's decision, Yacine left Conakry for his home in the Guinea highlands. He rode through steamy lowlands on a red road that winds up forested hills into a temperate cool, where the French were inspired to plant acres of pines to be made into railroad ties and two-by-fours. Yacine lived in a village about fifty miles from Labé, the regional capital. He returned home to the sweet grass glowing between the toes of downy goats and plaintive sheep. Voices of the village bubbled up and floated, accompanied by baas, cock crows and the blows of a hatchet. His home was set in the middle of a garden his wife cared for. On a bend of path by a twisted stand of fruit trees, he found a pattern marked out in the dirt before his house gate.

"Saran, come quickly!" His wife came out of the house and looked down with him at the pattern. A square was outlined and sprigs of greenery placed in each corner. A cigarette carton, a piece of glass, and a stone were scattered in the square. A single sandal was turned over, its scratched sole facing up. Fonio seeds were sprinkled over the upturned instep.

"Who could have done this?" Saran asked.

"Old man Diallo, no doubt. He threatened me at the court. If I go to the fields to plant fonio, I will die. So much for the modern law of the court."

Yacine went into the house, Saran at his heels. With her help he carried out a heavy water vase. They pushed it over on the square design, washing away the order in the pattern.

"Tell your brother to have his sons patrol the village," Yacine said. "Anyone connected to the Diallos should be escorted out. I am going to see the Governor in Labé. I will stay with Fatimata. Since she kicked out her husband again, she should have plenty of room for me."

The village had one beat-up Mazda at its disposal. Yacine headed back out in this car, driven by his son Daouda, the suitcase he had taken to Conakry unopened and still in the trunk.

When Yacine and Daouda arrived, carsick from the rough journey, Fatimata was home from her job as cook and cleaning woman. She worked for an American musicologist, Brenda Peters, who, like Fatimata, was a woman living alone. Fatimata had lit the kerosene lamps. She had an electric light in each room, but the city power was off till morning. When Yacine and Daouda surprised her, she was already working on a pot of fonio and a peanut sauce for herself. She soon had plates ready for everyone. Fatimata was known for the richness of her sauce, which sank happily into fluffy grains of fonio. She served fresh squeezed orange juice and, after dinner, cups of mint tea.

"I can't let Diallo think he can intimidate us," Yacine said to Daouda. "Any bond between us was broken twenty years ago. A master without servants is a ridiculous sight. Diallo is afraid of looking foolish."

Daouda glanced at Fatimata before speaking to Yacine. "Diallo is said to be a powerful magician, protected by unknown spirits. I have heard that he has a throw rug by his bed made of the skin of the army officer who tortured his son-in-law Mamoudou. Even during the worst terrors of the former regime, the government avoided confronting him."

"I have known Diallo since we were boys. He is the sort of man who thrives on fear. He never did have a sense of humor."

"So what are you going to do, kill him with a joke?" Fatimata asked. "Diallo acts like he is cock of the hill. Maybe the rooster protects him."

"Hush. Your brother and I are discussing a serious matter." Yacine turned back to Daouda. "Tomorrow I will ask the Governor to accompany us to the fields to mark out the division ordered by the court. If we are swift, Diallo may not have time to cause trouble."

"You have waited twenty years for this moment. Why are you in such a hurry?" Fatimata asked. "Perhaps Diallo needs some time to realize that he must comply with the law," "Fatimata, even you pay no attention to the modern law. If you did, you would still have a husband in your home."

"Amadou agreed that I would be his only wife. Then he took a mistress and told me it is none of my business."

"Amadou is right. According to the Civil Code, a man may take a mistress without giving grounds for divorce, as long as he does not live with her."

"I don't care what the Civil Code has to say, Amadou betrayed me. I bring home my wages and he wants to spend them on clothes for his little friend. That man told me school made me an immoral woman. When Brenda heard this, she went off like a teapot. Hee yi."

"Father, Fatimata is better off without Amadou. She is saving her money so she can start her own cloth dyeing business," Daouda said.

"Fatimata should raise her children. She has not even had a child. The market women earn money to buy medicine and pay the school fees of their children. For whom will Fatimata run a business? Will the business care for her when she is old? I should have married her off after her first menstruation, as her mother wanted, rather than sending her to school."

"You sent me to school because I pestered you to let me go. I even told you that if I went to school, then I could help the boys with their schoolwork. Now I am helping myself."

Fatimata had the dazzling black complexion that is brighter for being darker, like bare branches against the sky. She moved with unhurried grace. Maybe her stubbornness came from growing up the eldest child, expected by her parents to supervise her siblings and by her siblings to lead and champion them. Yacine was too tired to argue anymore. He went to bed in Fatimata's room.

"So what do you think about Diallo?" Daouda asked Fatimata.

"I think it's a mistake to fight him on his own terms. We're better off using the courts and government officials. We have gotten by without the land so far. But I can't blame Father for being impatient after twenty years."

"Suppose we do get into a fight? How do we counter Diallo's magic?"

"Maybe he does get his power from the rooster. Do you remember the story of Soundjiata and the evil king Soumoro Kanté? Soumoro Kanté also had a liking for throw rugs made of the skins of his enemies. They say he would slip off his sandals and pad about in his bare feet on these rugs."

Fatimata made up sleeping mats for herself and Daouda. Daouda went straight to sleep. Fatimata lay still, listening to crickets and the rumble of a truck, and watched Daouda. His face was utterly untroubled, slender ears and long eyelashes.

She got up and returned with a handful of rice. She sprinkled a few grains around Daouda and did the same for Yacine, who was also fast asleep.

She sat crosslegged on her blankets and again watched Daouda, her face resting in her hand as she thought. She whispered the names of her grandparents, now dead, of her great grandparents, of other deceased relatives whose names she could remember, and she invoked those whose names she had forgotten by referring to some famous deed still talked of in the family: the lion killer. . . the friend of bees. . . the discoverer of water springs. "Shield Daouda, who is too inexperienced to appreciate the meanness of a Diallo. Shield Yacine, the first of your children entirely free of noble rule." Fatimata only slept after she was sure that she had the attention of her ancestors.

The Governor's offices were in a rather dingy three-story building built thirty years before and poorly maintained since. The mud brick walls were eroded in spots, the paint chipped. Still the ceilings towered luxuriously high. In the absence of electricity, light through eight foot wood window shades filtered into the gloom of bare offices and hallways. This filtering of light was a sensibly cool design thirty years ago but now seemed to age the light instantly.

When Yacine and Daouda arrived, they were made to wait in a room on the first floor along with an assortment of other people in varied states of waiting. Several military men sat with their boots outstretched. A busy man rushed through every so often, sometimes tugging loose from a suppliant, sometimes leading someone out. Finally he stopped by Yacine and Daouda and had them follow him to a second floor office.

"The Governor's assistant will speak with you." He disappeared, leaving them in the hall. They could hear voices behind the assistant's closed door, so they waited. After a few minutes, they were allowed to go in.

"Peace be with you, Yacine. Is this your son?"

"Yes, Daouda is my youngest. Daouda, meet Mohammed Bobo Hitta."

"Pleasure meeting you, Daouda. I know your brother in the Public Works Ministry. We've been to the nightclubs in Conakry a few times."

"Bobo," Yacine said, "I am sure you know of the court's decision ordering the Governor to divide the land between us and the Diallos. I have come to insist that the Governor act right away."

"The Governor is prepared to follow through on the court's order, but he is sick with a bout of malaria. Give him two weeks, and then this matter will be settled."

"I can't wait two weeks. Old man Diallo is determined to intimidate me. He does not respect the court or the Governor. If I do nothing for two weeks, he will find some new way of delaying the division of the land, as he has for twenty years. In any case the planting season is almost over."

"If you go out to the fields without waiting for the Governor, there may be violence. Be patient a little longer."

Yacine shook his head no, shook hands with Bobo, and left with Daouda. In the courtyard of the Governor's offices, they met Diallo on his way in.

"Thanks for the fonio seed, Diallo. It'll come in handy when I start planting this Saturday."

"You are not planting this Saturday, Yacine. If you go off to the fields, they will have to carry you back in a cart, your head held low and your feet dragging."

"You can't stop me any more than you can hold back the floods from bringing silt onto the good bottomland."

"Water which can't be stopped can be diverted into irrigating my fields," Diallo said, giving Yacine a push. Daouda caught Yacine and swung at Diallo, but his fist seemed to pass through a ghost. Daouda stumbled and saw Diallo standing several yards away. Yacine grabbed Daouda, and they marched off. How do you fight someone who can disappear and reappear just out of reach?

They returned to Fatimata's home and ate the evening meal, prepared and served by Fatimata with her deliberate grace. The dishes cleared, Daouda pondered his question by the yellow flicker of the kerosene lamp. Daouda explained to Fatimata what happened earlier in the day. Fatimata gave Daouda a long tail feather of a cock.

"Tie this to one of your practice arrows, one with a blunt tip. If Diallo attacks, skewer his protecting spirit, and he'll realize how naked he is under his robes."

The next day, Yacine and Diallo went to the Mosque within walking distance of their villages but did not speak to each other. Yacine left immediately after services. Diallo stayed and sat with the council of elders, all of noble families.

Saturday morning Yacine set off for the disputed fields, accompanied by Daouda and a group of young men from the village. They carried machetes and hatchets for clearing the fields and an assortment of shotguns, some homemade from lengths of pipe bound with animal skins. The morning was cool, clear of mist, the sky almost cloudless. They walked over bushy, lightly forested hills and crossed streams where cabbage palms sprouted leaves like Mickey Mouse ears beside feathery stands of bamboo. Monkeys hooted warnings from the highest tree tops. They passed families already out in the fields. Mothers placed their babies on blankets while they hoed. People strolled around shaded by brightly colored umbrellas. Kids ran back and forth or crouched under thatched shelters, keeping an eye on foraging goats. Fields had been cleared and burnt over and the earth, turned by hand, looked soft and evenly brown.

They filed down into a valley ringed by green hillsides patchy with brown fields. The rich bottomland was thick with twenty years' growth of timber twisting up from the undergrowth. They began to hack at the trees but didn't get far before Diallo arrived with his group of young men, machetes, hatchets and shotguns. One of Diallo's young men, a shotgun in one hand, a machete in the other, ran angrily up to Yacine, who stood his ground. The young man fired a shot and somehow missed Yacine completely. He chopped at Yacine with his machete and opened a nasty gash in Yacine's leg. Someone from Yacine's group shot at the attacker, wounding him in the shoulder. People fell in the underbrush and fired blindly, most of the shot rattling into trees.

Daouda had brought only his machete and bow and practice arrows. He notched, drew back and shot the arrow trailing the tail feather of a cock at Diallo, who was partly shielded by trees but still visible in his bright robes. The arrow missed but whistled so close that the feather brushed Diallo's cheek. A bead of sweat sprang out of his forehead and rolled down to the tip of his nose. Quivering he ran back into the woods, followed by his young men.

The wounded of both sides were brought to Labé, to the only hospital in the region. Fatimata and Daouda sat with Yacine in his hospital room. The doctors wanted Yacine to stay overnight, so Fatimata brought a pot of fonio and peanut sauce. They could hear the police interrogating one of Diallo's young men in a hallway outside their room. "The blacks started it," the man kept saying. Yacine said nothing. He sipped water, and ate, a long pause between each bite. Daouda looked puzzled, as if disoriented by the glassy hospital surfaces, the stuttering fluorescent lights.

Fatimata thought about an incident that happened to Brenda Peters' sister. Brenda's sister had come from America for a visit and brought along her new baby, which she carried in a harness on her back. They were all at the market dickering over indigo cloth for Brenda's sister to take back home. When they left, they had to walk a narrow road back to the car, a road thronged with people but with no sidewalk, only an open drainage ditch on either side. A taxi driven by a young man plowed through this narrow road, forcing people to leap the ditch or climb down in it. The taxi driver crowded Brenda's sister to the edge of the ditch and then snagged the strap of her baby's harness on his side mirror. He did not stop, despite Brenda's furious screams, despite her sister's attempt to run with the taxi and free herself. Her sister was slowly pulled over and dragged and the driver was only stopped when someone deliberately pushed a cart in his path. Brenda's sister and baby were both unscathed, although terrified. Fatimata could not stop thinking of the inexorable progress of the taxi down the narrow street.

Anthony
Bukoski

The Korporał's Polonaise

Looking one last time at the Polish Eagle painted on the bow of the freighter *Pomorze Zachodnie*, we cursed the captain and scrambled down the gangway. That November day Mr. Lasinski, who worked at the four mill in the East End of Superior, never thought he'd be taking home a family of sailors along with the cartons of *Żywiec* beer he'd gone to the docks to buy from the crew.

After the newspaper articles, television reports, and INS interviews, a few months later as we clean palms in the church basement, we recall it all again for him, our sponsor. For a moment I think of the priest upstairs in the sanctuary. We fear St. Adalbert's Church will close like the other churches. Frightened of this, in confession later I will tell the priest why I left the Old Country. He will tell me his own fears for the new country.

"Bless me, Father," I will say.

"What are your sins, Kazimierz Wroblewski?"

"Despair, Father."

"I despair, too," he will say. "We're both desperate."

Every Sunday since I've been here the priest has carried his grief and mine to the altar. Tomorrow here and in the Old Country priests wear red vestments during the mass and distribution of palms. Tomorrow Marcella Dzikonski will play the organ in Superior, Wisconsin, the way my father did for many years in the Church of St. Bartholomew in Poland.

Mr. Lasinski calls our story "immigrant history," saying we should record it for future generations like Tomasz, my son's. "Will you tell more?" asks Stanislaus Lasinski when my thoughts return to what I was saying about a merchant seaman's life.

I tell him how, in Poland, my father will attend Palm Sunday mass. Later, tucking the palm behind the portrait of my mother on the wall of the room, he'll dream of her, then of me, Kazimierz, of Hedwig, my wife, and of young Tomasz, all come to the Seaway Port of Superior. "When I was very young, my own father carried me through the village like I once did my Tomaszu. 'Precious Kazik,' he called me. He kept me close to his heart," I tell Mr. Lasinski. "My father was organist at the church when I was small. *'Pan'* Organist, 'Sir' Organist, people called him. This was in 'the Land of Graves and Crosses.' This was my Poland. *To był moja Polska.'*

"This is the Poland you left with Hedwig, who was cook on the *Pomorze Zachodnie*, and with your Tomasz?"

"Yes. Life is no good where we came from. The Communists. Speak against them and you're a 'dwarf of reaction, *karzeł reakcji.'* 'Social noxiousness, *społeczna szkodliwość,'* they call it. For years we dreamt of coming here. The northeast wind brought us."

Hedwig looks out the church's basement window at our nine-year-old Tomasz playing in the schoolyard. Her eyes brighten. We need such joy before I tell how we've abandoned my father. *I wish I could send these remarks to you in Poland, dear father, so you could hear me recall your death and resurrection. Now you are so weary you must stop to rest your elbows on the table. When you roll your sleeves, your arms, I imagine, will be thinner than when I last saw you. My only hope is your dear smile so far away in Passion Time. How I miss you and regret leaving. What could I do? I have my wife, my boy. When you yourself once left me, can you now call your son, Kazimierz,* "cygan, *gypsy," for leading his family to America?*

Hedwig, who's been patiently cleaning the palms' silk threads and listening, says, "When a musician passed through during the war, he'd come to Kazimierz's house just as a visiting priest would look up a priest in the village, or a teacher, a teacher, a butcher, a butcher. Wanderers knew who lived where."

"I was very young, our Tomasz's age, when my father left. He joined the Home Army. Overrun, Poland fought back in 1939. *'Ojciec,* father,' I remember crying, asking him not to leave."

Now as I think of him, the silence moves rapidly. What have I done? When my dear father is at some distance from the son Kazimierz's heart, I begin again, more composed. "After he put me to bed, saying he'd see me in the morning, *Pan* Organist ducked into the forests. 'Where is father?' I asked grandfather when the sun rose.

"'Gathering mushrooms,' he said.

"'When will he return?'

"If you only know, Mr. Lasinski!" Hedwig says. "The Russian filth watched us then and now in 1985. Think of the Katyn Forest Massacre, think of 'the Flower of Polish Youth' slaughtered there in World War Two by the Russians. The heart yearns for them, Mr. Lasinski. And God help us what the Nazis did to Poland and the Jews."

"Now father had gone," I tell our sponsor from the flour mill. "I looked for him by the woodpile, by the pools where leaves swirled above the fish, by the church where no one practiced *'Bogarodzica Dziewica.'* Occasionally you'd hear whispered, 'An organist has come! An organist has come!' The first time I ran so hard to the fields near home, I stumbled over the wagon ruts but got up and kept on. It was the pattern I followed many times during the war. Scanning the roads, going farther each time, I muttered, 'Where is my father? Has he deserted us? Why can't he stay and protect me?'

"When father left, the house was silent. He's not praying for us. He's gone, I'd begun to think."

"How sad it sounds now," Hedwig says. She's washed kneelers, dusted windows, washed the church floor today. For Hedwig, who left only a cousin and a distant uncle in Poland, it may be a little easier forgetting the voyage. Nothing keeps me from remembering father today, however. The thought of the vigil lamp on the altar of St. Bartholomew's in our village in the Old Country—Christ's heart at the center of His church—keeps me remembering.

"What our country has suffered," Hedwig says. "Go on telling it."

"Rumors circulate," I say. "They swirl about the eaves, sweep down through the chimney. I remember how hard grandmother *Babusia* prayed when the rumor that father had died came to our door. Mother fell to her knees. People had heard it on roads, under trees, through open windows. In the late afternoon, I ran off. The priest came looking for me. An old country priest, he feared the devil and the forest. 'Think of your mother and grandmother,' he said, summoning his courage. He was old like the priest upstairs today. He'd borrowed Pomerinski's horse to come to get me. 'You must return home, Kazimierz' he said, 'not stay in these woods. You can't run away from truth.'

"'I'm waiting for father.'

"'What shelter do you have? asked the priest. 'You'll get cold. I don't want to be like the moon bringing trouble to your hearth. Come here tomorrow morning, but for now, please Kazimierz, I am old. I don't want to stay. Come now, please take the reins. I fear for our souls in these woods.'

"Mother rekindled the fire when we came home. 'Are you sure about the rumor?' the priest asked. 'Look in the ashes!' grandfather said.

"For months the priest told me, 'We must serve out God's design. Don't give up.' So I ran to the fields with hope and conviction. 'Have you seen father? Please,' I asked wanderers, 'have you word? He is as tall as you and strong. This *korporał* would be talking about playing the organ at the Church of St. Bartholomew. I am his Kazimierz. Did you see the man whose eyes are said to resemble mine? Why have we not heard from the *korporał?'*

"Once I thought we had news. A fearsome-looking Russian whose black eyebrows matched his eyes swore he'd tell me if I sang him 'Vlanka, the Heartbreaker.' He said it *'Vlanka Kliuchnik'* in Russian. When I sang, he said he must have another song. I said I didn't know another Russian song. 'I can't tell you my news then,' he said, laughing, walking off through the fields.

"Another time a man selling trapped souls came by. The souls weren't very heavy, but he was loaded down with them. They hung from his shoulders and belt in little boxes. Animals' souls, Russians' souls, everyone's souls. 'Get away. I don't want them loose on earth!' he said when I ran up.

"'Do you have father? Where are you going to put him?'

"'I'll bury him, sell him, place him in a tree. On windy nights, the box will sing to the tree:

Hi! Ho! Hi!
What a man am I!
Hi! Ho! Hi!
A valiant man am I!

"'Please can I see my poor father's soul so I may buy it from you for three or four *złotys*?"

"'You carry the box. Do no more than that. No peeking inside!'

"The man grunted. Sometimes he spit at my feet. His hair and face were greasy, it looked like, with the grease of Russian engines and motors and coal. This box was made of willow switches, clay, paste, string. I thought if I could free father, maybe war would end. When we got to the village, the man cursed me when I gave him the three-*złotys'* reward for rescuing father. 'There's a dog's soul, nothing else in that one, foolish boy. All the miles you've sung to a dog's soul and now paid me for it. I even know its name, 'Kurta the Dog.' I've tricked you. 'Hi! Ho! Hi! What a man am I! Here Kurta! Here, Boy,' he called and whistled for the soul.

"The priest watched me, crying, hang the empty box in a tree to listen for songs from the *korporał* when the wind blew. It was a silent country, though. The soul was gone.

"As ashes are swept from a hearth, so after awhile was my father's memory swept from the village. No one spoke of the *korporał* anymore. I wondered each day, has father sent a rumor through the wind only to make it look as though he's died? Is he buying a widow a loaf of Russian bread or a wick for her lamp? I shall not pray for him, I decided. Let the rumor go back that we're not praying for father whose kiss means nothing. The *korporał's* embrace can mean nothing ever again.

"Bless me, I have sinned," I confess over and over to another 'father,' the priest, in the Port of Superior. I've confessed here and at a church in

Duluth. *How can I have thought so of my father and at that age given my soul to despair? In what past or future am I?*

"'Have you other sins?' the priests ask.

"'Despair, sorrow, anger. We *had* to leave the ship. For Poles, a seaman's life is not so bad under Communist regime, but nothing is as good as being in your country in this northern port.'

"Then the priests ask, 'What other sins must you confess, Kazimierz Wroblewski, merchant seaman? Hurry before churches all close.'

"Despair, loneliness. We can't go back to him.'

"'Hurry! Hurry, our closing is imminent.'

"Over and over I tell the priests that Hedwig and I are the rumors of despair. Is our voyage worthy of retelling? Is it, when tomorrow my father will go to mass alone thinking of mother who died long ago, then thinking of the family that went to America? People will ask him after church, 'When will your Kazimierz return?' Later, he'll place the lunch bowl on the cloth, lie in bed, look out the window at the agent watching the house. I have such images of a beloved father—white hair brushed back, thin, white eyebrows over eyes closed on nearly a century of struggle, nose curved at the bridge, white moustaches. Now he must doubt me, his middle-aged son, and ask the Crucifix and the ashes in the hearth, 'Where has Kazimierz gone with his soul? On what sea is his soul tonight?'

"By midsummer, Mr. Lasinski (who has cared so well for us in America), I'd tell mother, 'I won't be out long tonight.'

"'So the news, is it good news on the roads you walk looking for your father?'

"'No, Mother,' I'd say, disappointing her. "No souls, though I sat with the trap open.' *This is the night she, too, will leave us. What will happen to me?* As the candle flickered, mother would open the latch door and, in the starlight, sweep leaves from the doorstep.

"'Why were you sweeping?' I'd ask.

"'Couldn't sleep. The news, Kazimierz?'

"'No good news, Mother.'

"What I learned I kept to myself. I'd hang the box in a tree at night. Soon I gave up believing I could trap father's soul; the twine that tied the willow switches broke on the box, and the paste and glue gave way on the box that trapped no soul.

"Now autumn and winter passed, and the long, cool spring of 1944 had begun when one day, walking to *Pani* Grotnik's, I saw two young sisters running toward me. 'An organist! An organist!' they cried. When they grabbed my sleeve and insisted, 'Kazimierz, a rider saw him!' I paid no attention.

"They were twelve years old. One of them had scuffed her knee. They went running to neighbors' houses.

"'Who?' people called.

"'Out on the post road. Everyone come!' Zosia and Marta were saying. 'An organist.'

"I'd run to the roads one hundred times. Now in the mist I saw someone. As Zosia and her sister ran, I dawdled, observing the pools of rain in the wagon tracks, the clumps of grass. What excitement could compel me to run? When I looked back, there stood grandfather at the cottage door.

"The priest trotting past on Pomerinski's horse was calling, '*Zprochu powstalés i w proch się obrócisz.* Dust thou art and to dust thou shalt return.' The distant figure—there one minute, in the next he'd be lost in the meadow blackthorns.

"How could a man be so haggard-looking? I wondered when he drew closer.

"'Grimy fellow!' one of the village women said.

"His coat trailed around him in the mud. I wondered whether this stranger would ask for 'Vlanka the Heartbreaker.'"

"War casts up odd, frightening people. Ghosts," Hedwig says.

"I'd come to hate the rags and filth of beggars—the embarrassment I suffered when they passed through. Zosia, her sister, the priest on horseback, the villagers—we kept watching this man stumble closer. Stopping a moment to adjust the rags he'd wound around his neck, he caught his breath, observed the millet fields, the old people who'd come out to see him. 'Christ has come,' they said. But it was no Christ they wanted. They'd been cheated.

"'Tell me of *Korporał* Wroblewski,' I said. 'I'll show you a box. I'll sing you an Easter song.'

"'A ghost!' Zosia said.

"'Do you know my father? Where is *Korporał* Wroblewski?' I asked.

"'Stand away,' said the priest, who started praying.

"'No one knows your father,' the man said. 'No one knows *Korporał* Wroblewski, who's dead.'

"'Does the devil not know *Korporał* Wroblewski?' asked the priest.

"'Yes, the devil,' said the man. 'The devil and I know him!'

"The women wiped their tears. '*Jesu,* no one even recognizes the devil anymore!'

"'Hi! Ho! Hi! A valiant man am I,' I sang, preparing to return home. 'I know him. It's a trick. He'll ask for something, three *złotys*, then tell you nothing. *Nie ma Ojca.* I have no father.'

"Beneath the dirt where the wanderer's skin had peeled, the new skin was white on his face. The dirt caked most of his forehead and cheeks. You could hardly see his eyes. Sometimes his lips moved. No sound came out. Bits of rags stuck to his hands, his fingers like crow's claws. 'I can go no further,' he said.

"'*Nie ma Ojca.* What a valiant man am I without a father,' I said. Imitating the slump of the man's shoulders, I circled him, repeated a rhyme from the old children's game *Raz, Dwa, Trzy:*

One, two, three,
The devil's watching, see?
Four, five, six,
Watch out for his tricks.

Another demon,' I said and struck him, struck the devil.

"*Babusia* was crying. '*O Boże.* Not dead.' I saw her making the Sign of the Cross. The priest, too, was whispering 'Christ!' Whoever it was, I'd been embarrassed before by a man carrying a dog's soul and could not understand what this wanderer was whispering to us.

"But the villagers now started saying it. 'It is the *Korporał Organista.*' Ha! *I* know the devil, I thought. No father leaves his son. The tricks this demon uses. I had learned so much in the fields, you see, Mr. Lasinski, that now *my* soul was trapped. You could write 'ANGER. SELFISHNESS. PRIDE.' on the box that held my soul. I have brought it to America. It is small enough to hold in the hand. I was a precious, selfish boy. I would not even recognize him that day or all during Holy Week, which now years later we celebrate in a free country where my soul is trapped in new delusions to help me forget.

"The whole week of his passion and resurrection I denied him until, one day late in the month of March, 1944, I saw him sitting alone, resting in the sun. He'd gained strength. He was smoking his pipe, smiling about something. Nodding to me, he said, 'Aren't you happy I'm home, Kazimierz. My little Kazik, I have been defending our country. Come, sing me a Polonaise, hum the melody for your father.'

"He said it so softly, Mr. Lasinski. They were like the words of God. Hearing them, I did as he said. He loved a Polonaise by Count Ogiński. 'La-la-la-la-la,' I sang it. I could see tears form in his eyes. Wiping them back for him, I went in the house then and buried myself in his coat. I kissed the buttons for many years afterward." *How selfish a youth I was in Poland, Dearest Father Korporał. Forgive me. Sometimes I have the hope that I can sing for you an Easter song, and we will be together. Then I know it's too late.*

"But this box! Hedwig, can you bring it to us, the box from the Old Country, the box with the Polonaise? It's delicate mechanism will play it."

"I'll get the music box upstairs, Kazimierz."

"Tomorrow the palms my father tucks behind mother's and grandmother's portraits will wither, Mr. Lasinski. Look at the palms in our church basement. Their scent reminds me of fields I ran through when father returned. Then to come home to see his son bewitched and turned against him. And to hear how his son thought he'd captured a soul! Today in March, 1985, the lamp in the sanctuary burns; the Pascal Candle is in its place in back of the church; *Korporał Organista* has come home to me again in my tale of Passion Week. I could not tell him to his face that we were planning to leave him last autumn. If I did, the despair would have been so great, I could not have lived. The thought of my father, the *korporał*, alone today—. Hedwig, bring the box! Play Ogiński's 'Farewell to My Country.'"

"I'm coming, Kazimierz. Patience."

"Raz, Dwa, Trzy!" my son's voice interrupts me. He is teaching others the "One, Two, Three" rhyme.

"Look, there's your Tomasz," Mr. Lasinski says.

In he walks just as I am finishing my story.

"Tomasz, son," Hedwig says. "Where have you been? Sing us *Raz, Dwa, Trzy."*

My boy's hair is tousled from the wind, his face wind-burned. He is excited, happy. He's made friends at St. Adalbert's Polish grade school at Twenty-Third Avenue East and East Third Street in the Seaway Port of Superior. Let me have time with him before he too must grow up and leave.

"Would you like to say something, Tomasz?" Mr. Lasinski asks. "We'd like to hear *your* opinion on matters."

He catches us by surprise. Out of breath, my Tomasz says, "I don't want to return to Poland. I want to stay in America."

"So do I, Tomaszu," I say, a merchant seaman from a village where my father waits alone praying for our return. "I don't want to, either. There's nothing but graves and crosses."

Now Hedwig, coming downstairs with a little box of music to trap souls, says it. "There's nothing to go home for."

Above us, in a church that is to close, the priest prepares for his last Palm Sunday as I open the music box on the table and find a lock of my father's precious white hair. Now the Polonaise he loved begins to play, but we cannot go back to him. We cannot return to the Old Country. All we have are its graves and crosses.

Notes on Contributors

Margaret Benbow is a life-long resident of Wisconsin who grew up in Sauk County, three miles from Devil's Lake. She earned her B.A. at the University of Wisconsin-Madison. Currently working on a collection of short stories and a novel, she has published many works previously, including much poetry, some short stories, and a novel. A prize-winner in several national poetry contests, she has published two chapbooks entitled *Poems by Margaret Benbow* (Quixote Press) and *Bride and Bear* (Quixote Press). Her newest book of poems is entitled *Stalking Joy* (Texas Tech University Press, 1997).

Martha Bergland has taught English at Milwaukee Area Technical College for the past thirteen years. She earned her undergraduate degree at Benedictine College in Atchison, Kansas, and two M.A. degrees at the University of Illinois and the University of Wisconsin-Milwaukee. Her first novel, *A Farm Under a Lake* (1989), was published by Graywolf and Vintage in the U.S., Great Britain, Sweden, and Germany. A second novel, *Idle Curiosity,* just appeared (Graywolf Press, 1997). Bergland's short story entitled "An Embarrassment of Ordinary Riches," first published in the *New England Review,* has been reprinted in two Pushcart anthologies.

Born and raised in Wisconsin, **Thomas Bontly** received his B.A. at the University of Wisconsin-Madison and his Ph.D. at Stanford University. For the past thirty years he has taught at the University of Wisconsin-Milwaukee, where he is Professor of English and Coordinator of the program in Creative Writing. Bontly's published fiction consists of four novels (*The Competitor,* 1966; *The Adventures of a Young Outlaw,* 1974; *Celestial Chess,* 1979; *The Giant's Shadow,* 1989) and twenty-two short stories. The latter have appeared in *McCall's, Esquire, Redbook, Denver Quarterly, The Sewanee Review, Cream City Review,* and elsewhere.

Superior, Wisconsin, is home in many ways to **Anthony Bukoski.** Born and reared in Superior, he now teaches there at his alma mater, the University of Wisconsin-Superior. His graduate degrees include the M.A. in English from Brown University, and the M.F.A. in creative writing and Ph.D. in English from the University of Iowa. Bukoski's short stories have appeared in *New Letters, The Literary Review, Quarterly West,* and other journals. He has published two collections of stories under the titles *Twelve Below Zero* (New Rivers Press, 1985) and *Children of Strangers* (Southern Methodist University Press, 1992) and is currently working on a third. In 1997 Bukoski was one of those featured in the Public Broadcasting System video documentary, "A Sense of Place: A Portrait of Three Midwestern Writers."

Born in Chicago, **C. J. Hribal** moved to Wisconsin when he was ten, grew up on a farm, and received his B.A. degree from St. Norbert College in De Pere, Wisconsin, and his M.A. at Syracuse University. A faculty member of Marquette University, he teaches creative writing and English. He also teaches fiction at The Warren Wilson College M.F.A. Program for Writers. Hribal is the author of *Matty's Heart* (New Rivers Press, 1984), a collection of short fiction, and *American Beauty* (Simon and Schuster, 1987), a novel. Recently, he has published the novella *The Clouds in Memphis* in *TriQuarterly* and short fiction in *Witness* and *The Sycamore Review.* A new novel, *War Babies,* is forthcoming. He also edited and wrote the introduction for *The Boundaries of Twilight: Czecho-Slovak Writing from the New World* (New Rivers Press, 1991). He has been awarded a National Endowment for the Arts Fellowship and a Bush Foundation Fellowship.

Tom Joseph grew up in Illinois but spent summers in northern Wisconsin. Since 1991 he and his family have lived year round in Manitowish Waters. He serves as the town of Manitowish Waters' municipal judge and is active in developing the North Lakeland Discovery Center, a nonprofit organization dedicated to exploring the natural, cultural, and historic resources of Wisconsin's northwoods. He holds a B.A. in psychology from Yale and a J.D. from Lewis and Clark Law School. Joseph's stories have appeared in *Atom Mind* and *Parenting* magazines, and his humor writing was honored by the Wisconsin Regional Writer's Association. Recently completed, *Two Points* is his first novel.

Born and raised in Milwaukee, **Julie King** earned degrees in creative writing at the University of Wisconsin-Green Bay (B.A.) and the University of Texas-El Paso (M.A.), and lived in Dallas, Shreveport, and San Diego before returning to Wisconsin. She has taught writing and creative writing at El Paso and at University of Wisconsin campuses in Green Bay, Oshkosh, and Parkside. Much of King's writing reflects her own experience and deals with the transplantation of a Midwesterner to other cultural and geographical areas. Her stories have appeared in *Wisconsin Review, Gulf Coast,* and *The Bridge;* her poetry has been published in many literary reviews and in the *1997 Anthology of Magazine Verse.* She was awarded a Wisconsin Arts Board grant for fiction in 1994–95.

Marnie Krause was born and raised in Milwaukee and attended MacMurray College in Illinois. A current resident of Michigan, she makes Green Lake, Wisconsin, her summer home. Her writing interests range from short stories to art plays. Krause is a member of the Michigan Playwrights Association and the Dramatist Guild. Her play "Axel & Viv" received an award from the Community Theatre of Michigan Association.

After working in Florida for eleven years, **Karen Loeb** moved to Wisconsin in 1988 and has been teaching creative writing and other courses at the University of Wisconsin-Eau Claire. Her story collection *Jump Rope Queen and Other Stories* was published by New Rivers Press after winning a Minnesota Voices Project Award. She has published stories, poems, and articles in magazines and newspapers, including *Habersham Review, North American Review,* and *South Dakota Review.* Loeb is the recipient of two literary fellowships and a grant from the Wisconsin Arts Board. Two of her stories received PEN Syndicated Fiction awards.

Peg Sherry has called Wisconsin home for nearly fifty years since her arrival as a student at the University of Wisconsin-Madison, where she earned B.A., M.A., and Ed. Admin. degrees. She taught for twenty-five years in the Madison schools, at Edgewood College, and in summer enrichment courses at the University of Wisconsin-Madison. Her short stories and creative nonfiction have appeared in several journals, most recently in *The Writer's Block.* She published her chapbook collection of poems and essays, *Lines from My Life,* in 1992. Twice she was awarded fellowships to Ragdale, the celebrated writers' retreat in Lake Forest, IL. Now in her "retirement" years, Sherry continues to write while volunteering in nursing homes, running an estate sales business, and enjoying the barnwood cabin she and her husband built in the woods near Briggsville.

Carol Sklenicka lives in Milwaukee, where she currently is researching a biography of Raymond Carver. Her work has been published in various magazines, including *Iowa Woman, Confrontation, Sou'wester,* and *The South Atlantic Quarterly.* Her critical study, *D. H. Lawrence and the Child,* was published by the University of Missouri Press in 1991. Sklenicka is the recipient of a Wisconsin Arts Board first place award for fiction.

David Tabachnick has commuted between Africa and Wisconsin since the age of eight, dreaming, he says, of hotdogs and marshmallows in Nigeria and the sound of drums on the night breeze in Madison. He holds a bachelor's degree from Hamilton College and degrees in law and sociology from the University of Wisconsin-Madison. His story "Mistral" won first prize in a University of Wisconsin-Madison creative writing contest. A number of Tabachnick's poems and a brief prose piece have been published in the anthologies *Lonesome Traveller* and *The Glacier's Edge* and in the *Wisconsin Poets' Calendar.*

Ron Wallace divides his time between his forty-acre farm in Bear Valley, Wisconsin, and Madison, where he directs the creative writing program at the University of Wisconsin-Madison and edits the University of Wisconsin Press Poetry Series. His Ph.D. is from the University of Michigan. Among his nine books are *Time's Fancy, The Makings of Happiness,* and *People and Dog in the Sun,* all published by the University of Pittsburgh Press. Wallace is a widely published poet in *The Atlantic, The New Yorker, The Nation,* and elsewhere. The recipient of two ACLS Fellowships and several Wisconsin Arts Board Fellowships, he was also winner of the first Robert E. Gard Wisconsin Idea Foundation Award for Excellence in 1990.

A native of Illinois, **Gordon Weaver** lived in Milwaukee from 1941 to 1961. His earned his B.A. in English at the University of Wisconsin-Milwaukee, the M.A. in English at the University of Illinois, and the Ph.D. in English and Creative Writing from the University of Denver. After teaching at colleges and universities in New York, Ohio, Colorado, Mississippi, and Oklahoma, he returned to Wisconsin in 1995 and took up adjunct teaching duties at the University of Wisconsin-Milwaukee and Marquette University. Some 90 of Weaver's stories have appeared in a wide variety of commercial and literary magazines. In addition, he has published four novels and eight story collections, the most recent of which is *Four Decades: New and Selected Stories* (University of Missouri Press, 1997). Recognition of his work includes the St. Lawrence Award for Fiction, the O. Henry first prize, two National Endowment for the Arts fellowships, and numerous other citations and awards.

David Young has lived in Madison the past eight years and has taught at Edgewood College the past three years. He completed his undergraduate degree at Duke University and his M.F.A. at Indiana University. His short stories have been published in *Ploughshares, Indiana Review, Hawaii Review, CutBank, Descant,* and other journals. In 1990 Young was awarded a Creative Writing Fellowship by the National Endowment for the Arts .

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

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Contents

TRANSACTIONS
Volume 86 • 1998

From the Editor

Charles Darwin's *The Voyage of the Beagle,* which chronicles his nearly five-year journey of discovery around the world in 1831–1836, is a classic both as natural history and as literature. A section I return to often is Chapter XVII, which records his amazing observations on the volcanic islands of the Galapagos Archipelago in September and October 1835. Here, for example, is his description of Chatham Island:

> Nothing could be less inviting than the first appearance. A broken field of black basaltic lava, thrown into the most rugged waves, and crossed by great fissures, is every where covered by stunted, sunburnt brushwood, which shows little signs of life . . . . The brushwood appears, from a short distance, as leafless as our trees during winter; and it was some time before I discovered that not only almost every plant was now in full leaf, but that the greater number were in flower. The commonest bush is one of the Euphorbiaceae: an acacia and a great odd-looking cactus are the only trees which afford any shade.

A few days later, after visiting Albemarle and Narborough Islands, the first of which Darwin characterizes as "miserably sterile" in large stretches and both of which he pictures as "covered with immense deluges of black naked lava," Darwin seemed almost relieved to finally note the presence of real trees, "several being two feet and some even two feet nine inches in diameter" on James Island.

How different are these scenes from typical September and October landscapes in Wisconsin, where trees reign supreme in their resplendent Fall costume!

As I write this editor's column in early October, I feel the lingering cold of today's brisk wind on my nose and cheeks. Inside my head I hear echoes of the fallen leaves crunched beneath my steps as I walked from home to my office. Traces of squashed fruit, fallen from the flowering crabapples, rub off the soles of my shoes to leave their tracemarks on floor tiles. Glancing through my window, I am delighted to see clouds dappling a bright blue sky. As they flee across the face of the sun, they alternately brighten and shadow the palette of colors displayed by the deepening hardwoods: cascades of crimsons and purples; bursts of red and orange wreathed by browns, greens, and pale yellows; and, here and there, the stippling of silver and gold.

I admit it. I'm a sucker for trees. They carry a nearly mystical quality for me. Outside our campus day care center stands a great American elm, an unbowed survivor of the devastating Dutch elm disease infestation of some years back. On any given day I, like a hobbit in a Tolkien novel, fully expect it to lean down and solemnly inform me in ancient Ent language that it has observed my comings and goings for the past 26 years. Then I will ask if it has heard the many whispered one-way conversations I have addressed to it and whether I was correct to assume that, just as I have prayed for its continued flourishing year after year, it, too, has been interceding for our campus community in its own inscrutable way.

And then there is the Cameron oak, one of the proudest trees in Oshkosh, entwined by legends and rumored to have shaded great native American council meetings in past centuries. This genuine wonder, whose wide-spreading lower boughs reached out so many yards that they had to be propped up to keep them from bowing all the way to the ground, succumbed a few years ago to a storm. Hundreds of Oshkoshians came to see the last hours of the fallen giant, driving past in funereal procession, silently stopping to take farewell snapshots and ship off branches as mementos, and gravely conversing on the sidewalks about the common loss. In my home I now have a prized relic from this grand oak, a wooden bowl turned from one of its limbs by a local artist. One day, as I rub its burnished surface, a genie is bound to leap out!

This issue of *Transactions* celebrates oak trees and their habitat, specifically, the great oak savannas and woodlands that once were dominant ecosystem types over much of central and southern Wisconsin prior to European settlement. Now, due to agricultural development and fire suppression, these oak habitats are becoming very rare.

The Memorial Union at the University Wisconsin Madison was the site of the 1997 Midwest Oak Savanna and Woodland Conference, part of a series held every other year, rotating among Midwestern states. The meeting was organized by a committee chaired by Alan Haney (UW Stevens Point) and including Mark Boyce (current Vice-President Letters of the Wisconsin Academy), Nancy Braker, Gary Eldred, John Harrington, Rich Henderson, Mark Leach, Evelyn Merrill, and Bob Wernerehl. Featured at the conference were plenary sessions, paper presentations, roundtable discussions, and field trips, all devoted to sharing information about the ecology, management, and restoration of oak savannas and woodlands in Wisconsin and the Midwest.

We are pleased to include in *Transactions* eighteen articles arising from this conference. All represent papers first presented at the meeting, subsequently revised and peer-reviewed for publication. Special thanks are due to Mark Boyce, who solicited the article submissions and helped in identifying suitable reviewers for the manuscripts. In addition, I know that all the authors join me in expressing gratitude and appreciation to the many reviewers who, by their incisive critiques and helpful comments, contributed substantially to the final shape of these articles.

Other articles grace this issue of *Transactions* as well. Three deal with Wisconsin fauna, namely, white-tailed deer, beaver, and black bears. The remaining two, which centered on literary "firsts" in Wisconsin, represent our special farewell to Wisconsin's Sesquicentennial celebrations.

We trust that you, the readers of the 1998 *Transactions,* will find within its covers a landscape not at all resembling those "miserably sterile" reaches Darwin visited in the Galapagos. Rather, we hope you will find a colorful array of informative, challenging, and sometimes entertaining articles on these pages. Like the trees putting on their autumn displays in Wisconsin, may they also carry seeds of new growth!

Bill Urbrock

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Roger C. Anderson

Overview of Midwestern Oak Savanna

Abstract *The eastern prairie-forest transition extended as a broad arc along the eastern edge of the mixed and tallgrass prairies from the Canadian provinces of Alberta, Saskatchewan, and Manitoba southward into Texas and was a mosaic of prairie, savanna, and forest. The three communities were not distinct, forming a continuum of vegetation that ranged from prairies to forest through the transitional savanna that shared species with forest and prairies. Savannas had scattered to low densities of trees with an understory that had a high component of species associated with tallgrass prairie. A majority of the plant diversity occurred in the ground cover. Savannas required landscape-scale disturbance (repeated fires) for maintenance of diversity and stability. The origin of the Midwestern savanna is recent. Savannas and prairies replaced mesic forests 3,500 to 8,000 years before present during the Hypsithermal, a warm, dry period associated with an increased frequency of fires. Following the Hypsithermal the climate became cool and moist. Stabilization of vegetation is credited to fires set by native Americans and occasional lightning strikes under a climatic regime that could support prairie, savanna, or forest. The mosaic of vegetation types including prairie, forest, and savanna that characterized the vegetation of the Midwest resulted from the interaction of climate, topography, and fire. Nearly all historic tallgrass savanna was lost as a result of agriculture, urban development, and fire suppression at the time of European settlement, which allowed conversion of many remaining savannas to closed hardwood forests.*

During the past ten years, there has been a growing interest in savannas expressed by scientists, persons working with private and publicly supported conservation organizations, as well as interested members of the general public. In many instances, non-scientists were unaware of the extensive literature available on savanna communities, including their origins, distribution, and ecology. This has resulted in misunderstandings of what savannas are and how they should be managed. In this paper, I summarize some of the literature that considers the natural history and ecology of Midwestern savannas. This summary is intended to increase understanding of savannas and aid in their management and preservation.

Distribution of Midwest Savanna

Midwestern savannas occurred on the eastern edge of a large triangular-shaped grassland that extended from the shortgrass prairies east of the Rocky Mountains into the Midwest where tallgrass prairie was the dominant grassland type (Risser et al. 1981). At its eastern edge, the grassland became increasingly fragmented and interspersed with forest and savanna, forming a broad transition zone to the eastern deciduous forests and conifer forest in the north. This eastern prairie-forest transition (Figure 1) extended as a broad arc along the eastern edge of the mixed and tallgrass prairies from the Canadian Provinces of Alberta, Saskatchewan, and Manitoba southward into Texas (Anderson 1983). Within the transition zone, prairies decreased in importance from west to east, whereas the importance of forests increased along the same gradient primarily in response to changing climatic conditions. From west to east, the climate becomes progressively less suitable for the growth of C4 prairie grasses and more favorable for trees, as periodic drought and low humidity during summer decrease and annual precipitation and its reliability increase (Borchert 1950, Risser et al. 1981). Savannas are a

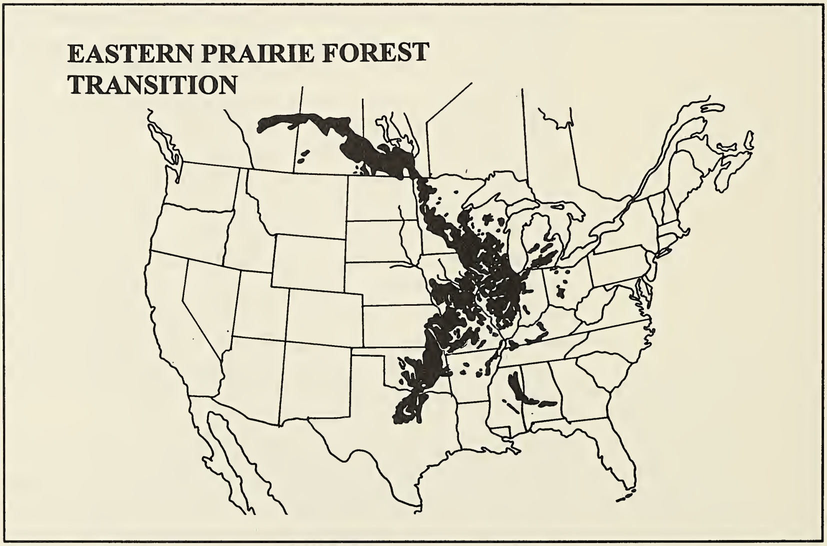

Figure 1. The eastern-prairie-forest transition extended as a broad arc along the eastern edge of the tallgrass prairie and was a mosaic of prairie, forest, and savanna (adapted from Anderson 1983 and Nuzzo 1986).

transitional vegetation, sharing species with the western grasslands and the eastern forested communities. The transition zone also varies along its north-south axis as illustrated by a continual change in savanna tree species composition and abundance. This change is reflected in the dominance of white, bur, and black oaks *(Quercus alba, Q. macrocarpa, Q. velutina)* in the northern and central regions, whereas post oak, blackjack oak, and Texas hickory *(Q. stellata, Q. marilandica, and Carya texana)* are prominent in the cross timbers savanna of Kansas, Oklahoma, and Texas (Curtis 1959, Rice and Penfound 1959, Anderson 1983, Hogland et al. in press).

Eastward through the prairie-forest transition, forest increasingly dominated the landscape, and savanna and prairie occupied less area. For example, in Wisconsin historic oak savannas covered about 3,889,640 ha or about 27.5% of the state, but they were concentrated in southern Wisconsin where savannas covered about 75% of the landscape (about 2.3 million ha) (Curtis 1959, Leach 1996). Eastward from Wisconsin the occurrence of savannas decreased, and only about 3.7% of the townships in Indiana had some oak savanna at the time of the Government Land Office Surveys (between 1799 and 1846). Oak savanna declined rapidly from west to east in Indiana, with oak savanna only occurring in the western third of the state (Potzger et al. 1956). In Ohio, oak savanna encompassed about 0.4% of the landscape prior to European settlement (Gordon 1966). All of this savanna occurred on sands in northwest Ohio (Fulton, Lucas, and Wood Counties). However, Whitney and Steiger (1985) reported that the Sandusky Plain, to the south and east (Marion, Wyandot, and Crawford Counties) of the savannas mapped by Gordon (1966), historically was 48.2% savanna. Adding the Sandusky Plains savannas, with fine textured lacustrine soils, to that reported by Gordon (1966) brings the total area of historic savanna in Ohio to about 0.8% of the state.

Defining Savanna

Recently, there has been discussion about the kind of vegetation that is described by the word savanna. Some ecologists have defined savanna as being grassland with trees (Packard and Mutel 1997). Nevertheless, there is no single definition for the word savanna that would be accepted by a majority of ecologists. The term is used to describe a variety of vegetation types. Vegetation described as savanna in one locality can be called by different names in others. According to Kline (1997), savanna is derived from the Spanish word *saban.* Spanish colonists adopted the word from a native Caribbean Island language in the sixteenth century. They used it to describe flat, grassy, treeless areas found on the Caribbean Islands. By the end of the nineteenth century, savanna became a name widely used for tropical grasslands of many types, with or without trees (Kline 1997). In Illinois in the 1700s and 1800s, savanna referred to grasslands with few or no trees. Immigrants from Great Britain used the word as a substitute for prairie (White 1994).

Several authors used savanna tree canopy coverage as a criterion to separate savannas from other vegetation types. Curtis (1959) defined savannas to have more than one mature tree per acre (2.5 trees/ha), but less than 50% tree canopy cover. Prairies had less than one mature tree per acre (0.4 trees/ha), and vegetation with more than 50% tree cover was classified as forest. By comparison, the Illinois Natural Areas Inventory considered savanna to have more than 10% cover, but less than 80% canopy cover (White 1978), while The Nature Conservancy

(TNC) classified savanna as having 10–30% tree canopy cover. In its classification scheme, TNC also recognized prairie (less than 10% cover), woodland (30–80% cover) and forest, which had more than 80% tree canopy cover (Taft 1997). Elsewhere, savannas were defined to have tree canopy cover ranging from 10 to 50% in Missouri (Nelson 1985) to complete canopy closure in Ohio (Nuzzo 1986).

Nature of the Savanna Community

Prairie-Savanna-Forest Continuum

Prairie, savanna, and forest vegetation are not distinctive vegetation types, but rather they blend into one another, forming what is termed a vegetation continuum (Figure 2) (Anderson 1991*a*). Savanna is the transitional vegetation type between the prairie and forest. Open savannas, that is those with low tree canopy cover, have a high component of species associated with prairies. Along a gradient of increasing tree canopy cover, the importance of the species with high affiliation with prairie decreases, while species associated with open forest increase in prominence (Figure 3). Several studies have demonstrated a gradual change in species composition across the environmental gradient from open prairie to savannas with increasing amounts of tree canopy cover to closed canopy forests (Bray 1958, 1960; Curtis 1959; Pruka 1994*a*, 1994*b*; Leach 1994, 1996). Some species of plants and animals reach their highest abundance in savanna and are adapted to the heterogeneous environment of savannas, with scattered trees or clumps of trees interspersed with open areas. Nevertheless, there are apparently few if any organisms that are restricted solely to savanna (Curtis 1959, Leach 1996).

The varied definitions of savanna likely result from the dynamic relationships occurring between forest, savanna, and prairie and reflect the difficulty of separating a vegetation continuum into discrete classification units. In addition, regional variation affects vernacular usage of terms to describe this transitional vegetation. Barrens, oak openings, glades, or savannas are all terms that have been used to describe the transitional vegetation types containing elements of prairies and forests (Heikens and Robertson 1994). Barrens also included brush prairies, sand barrens (that are similar to sand prairies in terms of herbaceous species composition), and the Hill's oak *(Quercus ellipsoidalis)* and jack pine *(Pinus banksiana)* barrens that occupied sandy soils in the central and northern portions of Michigan, Minnesota, and Wisconsin.

Savanna Common Features

Despite the lack of a common usage for the word savanna, vegetation described as savanna in the Midwest share features in common. They had open canopies, and the dominant trees were a few species of oak. The ground cover often had a high component of species associated with tallgrass prairie, and a majority of the plant diversity occurred in the ground cover. Savannas required landscape-scale disturbance (repeated fires) for maintenance of diversity and stability (Taft 1997). Trees in savannas have a characteristic open-grown form with broad spreading crowns and large branch scars along their trunks. Large branch scars result from the lower branches remaining on the trees for an extended period of time before they are self-pruned. In contrast, lower branches of forest-grown trees are shaded by adjacent trees and contribute little energy to the tree through photosynthesis. Consequently, these branches are soon pruned, leaving small branch scars that are incorporated in the bole

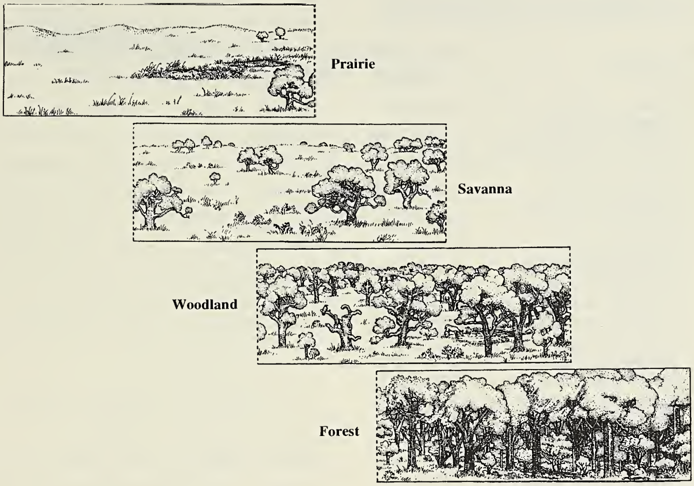

Figure 2. The prairie-forest continuum is characterized by continuous change in tree density and canopy closure from the nearly treeless prairie through the transitional savanna to closed-canopied forest. (Adapted from Packard and Mutel 1997 and granted with permission from *The Tallgrass Restoration Handbook,* Stephen Packard and Cornelia Mutel, eds., © 1997 The Society for Ecological Restoration. Published by Island Press, Washington, D.C. and Covelo, CA.)

as the tree grows. Forest-grown trees have narrow crowns with "clean boles," because of shading from adjacent tree crowns.

Oak grubs, a characteristic feature of some savannas, were oaks with tops one to a few years old but with root systems up to centuries old. Because of nearly annual fires, the tops of these trees would be killed to the ground, but shoots would sprout from the root system. Over a period of years, a massive root system, often with a large surface root crown (basal plate), developed that supported a shoot that would survive until the next fire. The term "grub" is derived from a German word *gruben,* which means to dig. European settlers laboriously dug these massive root systems from their agricultural fields, hence the name oak grub (Curtis 1959).

Black oak is less fire resistant than bur oak and was top killed by intense fire and converted to oak grubs, whereas the shoots of bur oaks develop thicker bark at an early age that more effectively prevents fire damage to the vascular cambium. In some historic savannas, a few bur oaks per acre occurred as scattered open-grown trees in a matrix of prairie grasses and forbs. In addition, there might have been a scattering of oak grubs, often black oaks, which were mostly hidden from view by herbaceous vegetation. These

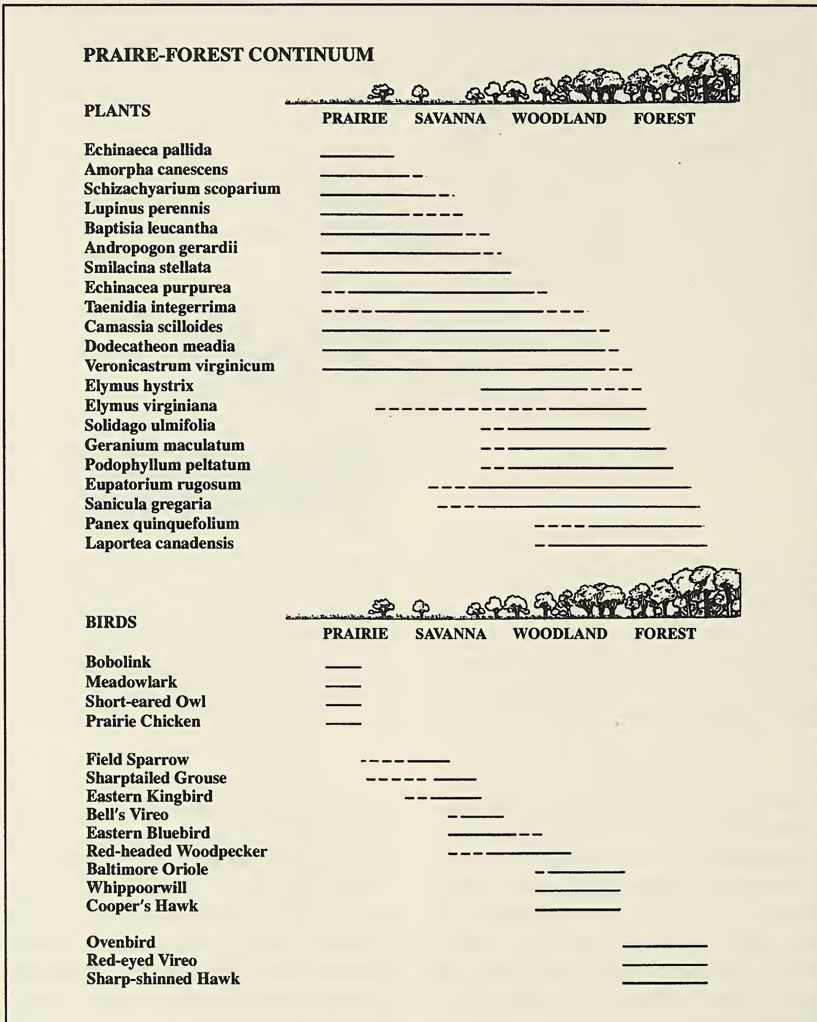

Figure 3. The continual change in species composition across the prairie-forest continuum illustrated for selected plant and bird species. Lines for each species indicate the portion of the continuum in which the species occurs. The species distributions were generalized from the author's field experience with plants. Bird distributions were determined in consultation with Dr. Angelo Capparella (Department of Biology, Illinois State University).

savannas, often called oak openings, had an orchard appearance with scattered bur oaks dotting the landscape (Anderson and Bowles in press). Muir (1965) described oak opening with oak grubs as a feature of historic oak openings in Colombia County, southern Wisconsin. Because "oak grubs" could be very numerous, conversion from savanna to closed forest occurred rapidly as the extensive root systems gave rise to rapidly developing shoots. The often massive open-grown bur oaks would be surrounded by the younger, narrow-crowned black oak shoots as the forest developed (Cottam 1949, Curtis 1959).

Savanna Modal Species

Comparing studies that use different definitions of savanna potentially can create misunderstandings and confusion. For example, Packard (1993) expressed some concern over the paucity of modal species (nine) that Curtis (1959) found in one type of savanna in Wisconsin, the oak opening. Modal species for a community have their highest percent presence in a given community based on quantitative data (Curtis 1959). The low number of modal species in oak openings indicates that few species of plants are more frequently found in oak openings compared with other communities and, as such, can be used to characterize savanna vegetation. However, Curtis (1959) categorized oak openings, oak barrens, pine barrens, and cedar glades as types of savanna vegetation. When these other savanna types are considered there are considerably more modal species. Nineteen species were listed as modal for oak barrens, pine barrens had 5 modal species, and 24 modal species were recognized in cedar glades, so collectively savannas had 57 modal species. This does not mean that these species occurred only in savanna, but rather they occurred in savanna more often than other types of plant communities sampled by Curtis. Furthermore, the number of species that occur predominantly in a community type is a function of the portion of the prairie-savanna-forest continuum that the community encompasses. If Curtis's definition of savanna was broadened to include areas with as much as 80–90% tree canopy cover, as with some definitions, the number of modal species would have been larger. Consequently, conflicting perceptions of the number of modal species found in savannas appear more related to definitions and semantics than to ecology. In addition, Leach (1996) noted that savanna vegetation was converted to woodlands and closed oak forests following cessation of frequent fires at the time of European settlement. Thus, some of the species that were prominent in historic savanna may have been considered to be forest specialists by Curtis (1959).

Origin of Midwest Savanna

Holocene Chronology

The savannas of the Midwest are of recent origin developing following the Wisconsinan glaciation. Analysis of Holocene fossil pollen deposits provides a record of vegetation change during the last 10–12,000 years and documents the origin of savannas during this time. Savannas leave pollen profiles that are different from those of prairies or forests. Savanna pollen profiles have a smaller proportion of hardwood pollen and a larger percentage of herbaceous pollen than forests, but a higher percentage of oak pollen and a lower percentage of herbaceous pollen than prairies (Griffin 1994).

Immediately following the Wisconsinan glaciation, conifer forests occupied much of the Midwest. Mesic hardwood forests replaced conifer forests 9,000–10,000 years before present (BP). On mesic sites, shade-intolerant oaks could not compete with the shade-tolerant mesophytic trees (beech [*Fagus grandifolia*], sugar maple [*Acer saccharum*], elms [*Ulmus* spp.] and basswood [*Tilia americana*]). Many species of oak probably were restricted to sites with low nutrient and moisture availability where they would receive less competition from more mesophytic species. Midwest savannas originated during a relatively warm and dry postglacial period known as the Hypsithermal (Altithermal or Xerothermic in older literature) that peaked about 3,500 to 8,000 BP. The actual time of the Hypsithermal apparently varied within the Midwest (McAndrews 1966; King 1981; Baker et al. 1992; Griffin 1994; Winkler 1995, 1997). In Illinois, the drying trend of the Hypsithermal began about 8,700–7,900 BP. Prairie influx into central Illinois occurred a few hundred years later (about 8,300 BP) with a concomitant displacement of mesic forests by oak forests in northern Illinois. During the hottest and driest part of the Hypsithermal in Illinois (about 8,000–6,000 BP) prairies occupied most of the state (King 1981).

According to Griffin (1994), oak openings appeared in northern Illinois and southern Wisconsin about 5,500 BP. Pollen record and charcoal deposits from Lake Mendota sediments in southern Wisconsin indicate that the climate was drier and hotter and fire frequency higher between 6,500 to 3,500 BP than it was in the early Holocene (Winkler et al. 1986; Winkler 1995, 1997). Oak savannas were associated with the warm dry period during the Holocene, but after 3,500 BP the climate became cooler and more moist, and closed *Quercus* forest dominated the landscape (Winkler et al. 1986; Winkler 1995, 1997). This appears to be in conflict with the generally held view that oak savanna dominated southern Wisconsin immediately prior to extensive European settlement (Curtis 1959, Leach 1996). However, this may reflect the patchy nature of vegetation distribution. The vegetation influencing Lake Mendota pollen records could have been locally dominated by closed forest in a landscape in which savanna predominated.

In northeastern Iowa, pollen records indicate that forest dominated from about 8,000 to 5,100 BP, and then it was replaced by prairie (Baker et al. 1996). Replacement of forest by prairie probably resulted from a climatic shift that increased flow of arid Pacific air and increased frequency of fires. Oak savanna appeared in northeast Iowa about 3,000 BP. These records would support those from other regions in the Midwest with replacement of forest by vegetation (prairie) adapted to a hotter and drier climate and increased fire frequency after 5,100 BP. Invasion of oak savanna after 3,000 BP in a prairie-dominated landscape would suggest that the climate was becoming cooler and more moist, consistent with the results of other studies (Winkler et al. 1986; Winkler 1995, 1997).

Landscape Level Changes

To explain the historic distribution of nearly treeless mesic tallgrass prairies on level to rolling landscapes, Curtis (1959) proposed that during the early part of the Holocene these sites supported mesic forest. The tree species dominating these forests—sugar maples, beech, basswood, ironwood *(Ostrya virginiana),* and others—were shade tolerant but not fire resistant. Shade-intolerant oaks were excluded from mesic sites because they were unable to compete with the shade-tolerant mesophytes. On droughty and/or low nutrient sites, e.g., sites with sandy soil, steep upper slopes, or sites with shallow soils over bedrock, the mesophytes were unable to tolerate the site conditions. In contrast to the mesic tree species, most oaks are tolerant of droughty, low nutrient environments, and they probably dominated these locations (Figure 4).

During the Hypsithermal the combination of drought and fires eliminated mesic species from all but the most sheltered sites, and they were replaced by tallgrass prairie. Most oaks have fire-resistant bark, and all oaks have the ability to resprout after being top-killed by fire (Stearns 1991, Abrams 1992). The hot, dry conditions and frequent fires associated with the Hypsithermal were unable to eliminate oaks, but repeated fires kept their densities low, forming oak savannas and woodlands (Figure 4).

Following the Hypsithermal, and after about 3,500 BP, the climate became cool and moist, and there was a shrinking of the area of prairie in the Midwest (Delcourt and Delcourt 1981, King 1981). Stabilization of vegetation is accredited to fires set by native Americans and occasional lightning strikes under a climatic regime that could support prairie, savanna, or forest (Curtis 1959; Anderson 1990, 1991*b*). The mosaic of vegetation types including prairie, forest, and savanna that characterized the vegetation of the Midwest resulted from the interaction of climate, topography, and fire. The relative importance of these interacting factors determined the prominence of these vegetation types on the landscape.

Distribution of Savannas on the Landscape

Fire frequency determined the occurrence of the three vegetation types on the landscape, and fire frequency was largely controlled by topography. Fires spread rapidly on level to gently rolling topography. On these landscapes there were nearly annual fires, which supported tallgrass prairies that required frequent fires for their maintenance in the climate of the Midwest (Curtis 1959; Risser et al. 1981; Anderson 1982, 1990). In dissected landscapes, the spread of fire was reduced, permitting the establishment of trees. Fires rapidly move up slopes, driven by rising convection currents, but as fires move down slope the rising convection current moves against the direction of the fire (Figure 5). Closed forest occurred in areas sheltered from fires, such as ravines or along waterways that served as fire breaks. These sheltered locations supported shade-tolerant but fire-sensitive mesophytic tree species such as sugar maple, basswood, and beech in the eastern portion of the prairie-forest transition. Fire-tolerant oaks dominated woodlands and savannas in areas where fires occurred less frequently than in the prairies, but with shorter return time than in closed mesophytic forests (Gleason 1922, Curtis 1959, Anderson and Anderson 1975, Rodgers and Anderson 1979, Grimm 1984, Anderson 1990, Abrams 1992).

Waterways also functioned as firebreaks. The west side of streams and rivers tended to be vegetated by prairie, because fires tended to be carried by prevailing westerly winds, whereas the sheltered east side of waterways supported forests (Gleason 1913). Easterly winds could have carried fires to eastern sides of waterways. However, east winds originate from the back side of passing high pressure systems and are associated with low pressure systems that bring in high humidity and precipitation that reduce the likelihood of fire.

Using a map (Figure 6*a*) of the historic distribution of forest/savanna and prairie in Illinois (Anderson 1970) and a map of the

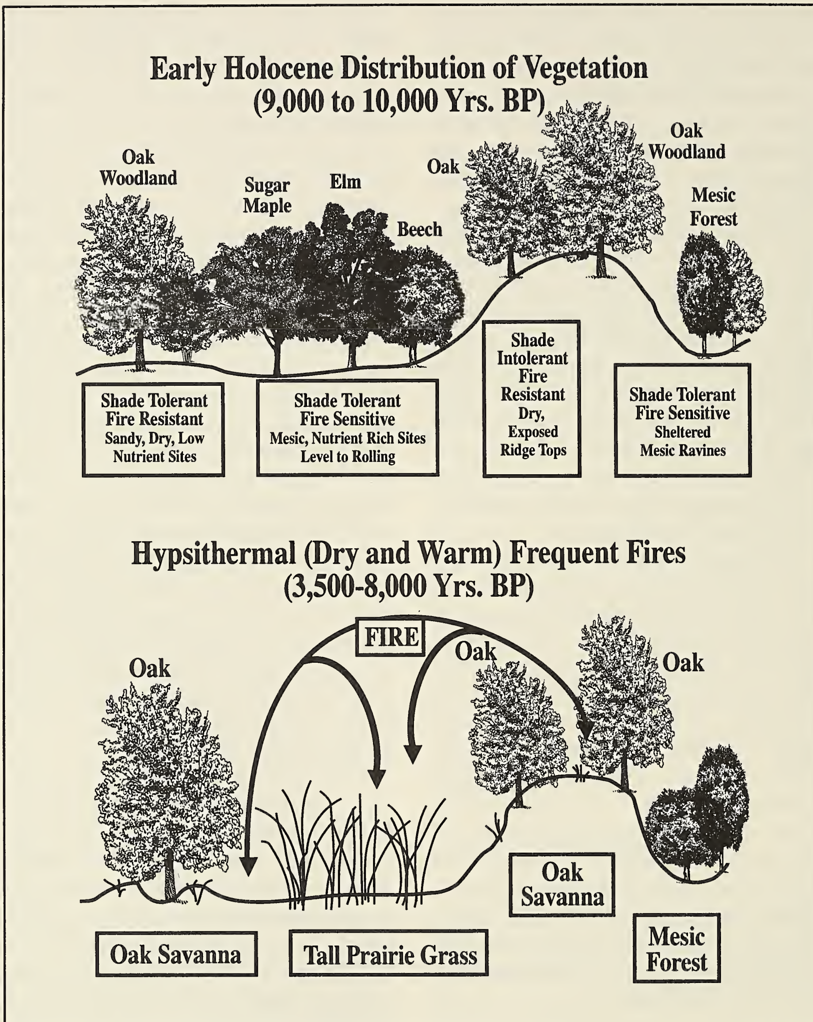

Figure 4. Possible change in vegetation distribution on the landscape from the early Holocene when the climate was cool and moist to the Hypsithermal that was associated with a warm, dry period with an increase in fire frequency.

average slope range for the state (Figure 6*b*), Anderson (1991*b*) examined the relationship between topographic relief and vegetation patterns. Forests-savanna were areas described in plat maps associated with the Government Land Office survey records as being "timber" and included varying mixtures of forest and savanna (Anderson and Anderson 1975, Moran 1976). Average slope range, given in three categories (2–4%, 4–7%, and >7%), was assumed to be a measure of topographic relief. Most prairie vegetation (82.3%) occurred on landscapes in the 2–4% category (Table 1). Only 23% of the forest-savanna vegetation was associated with 2–4% slope category, and most of these forests-savannas were on flood plains. In contrast, 77% of the timbered vegetation occurred on sites that had average slope ranges greater than 4% (4–7% slope = 35.2% and >7% slope = 41.8%). Most of these sites were associated with the highly dissected portions of the Illinoian glacial till plain, unglaciated areas, glacial moraines, and waterways.

Dry Savanna

On extensive areas in the Midwest, savannas and open woodlands also occurred on sites that had sandy, acidic soils with low nutrient availability and poor water-holding capacity. These sites were associated with glacial outwash plains (Curtis 1959, Pregitzer and Sanders in press, Will-Wolf and Stearns in press) and deep sand deposits in river flood plains (Anderson and Brown 1986). These sites supported herbaceous vegetation with low fuel loading. However, they were prone to fire, because the low water-holding capacity of the soil resulted in frequent and rapid drying of fuels that increased

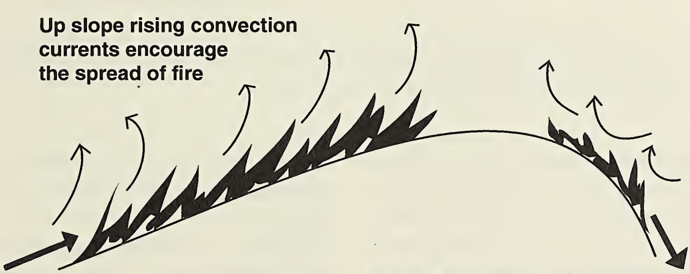

Figure 5. Influence of topography on the spread of fires. Rising convection air currents move fire rapidly up slope, but as fire move down slope the direction of the convection currents works against the spread of the fire.

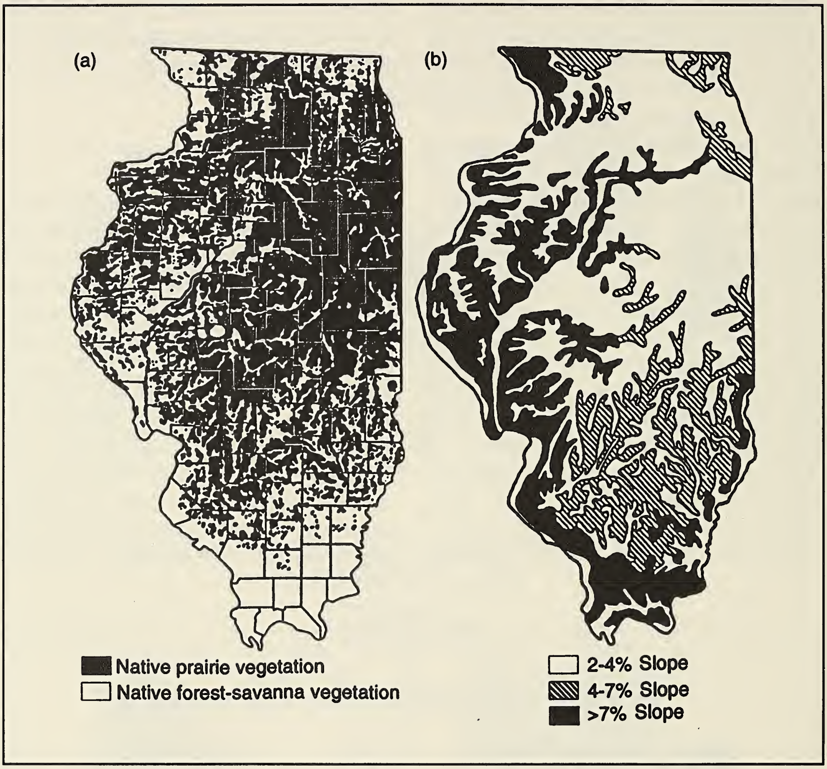

Figure 6. The relationship between landscape dissection and vegetation in Illinois near the time of European settlement from Anderson (1991*b*).

susceptibility to fire. With frequent fires that impeded the buildup of woody plant fuels, the fires were of lower intensity than those occurring on mesic sites with silt loam soils that supported tallgrass prairies with high fuel loading. These conditions permitted the co-existence of a mixture of sand prairie grasses and forbs and oak trees. Black oak was a common savanna tree in southern locations, and jack pine and Hill's oak were important trees in savannas in the northern Great Lakes Region (Curtis 1959, Grimm 1984, Anderson and Brown 1986, Pregitzer and Sanders in press, Will-Wolf and Stearns in press).

Calcareous dry savannas occurred on sites with thin soils over calcareous bedrock or gravels. White oak and bur oak were important tree species in these savannas that tended to occur in small scattered patches (Will-Wolf and Stearns in press). Cedar glades were another type of dry calcareous savanna that had an understory of dry prairie species and scattered red cedar trees *(Juni-*

Table 1. Percentage historic forest-savanna and prairie vegetation occurring with various slope-range categories in Illinois from Anderson (1991*b*).

Vegetation Type	*Average Slope Range Categories*		
	2–4%	*4–7%*	*>7%*
Prairie	82.3%	12.4%	5.3%
Forest-savanna	23.0%	35.2%	41.8%

perus virginiana). These savannas usually occurred on south- to west-facing slopes on sites with shallow soils over limestone bedrock. In the absence of periodic fires, limestone glades tend to undergo vegetation change forming nearly closed stands of the fire-sensitive red cedar with little ground cover vegetation. The open cedar glades grade floristically into hill prairies or high lime prairies (Curtis 1959).

Current Status of Savannas

Deep-soil (Mesic) Savannas

After European settlement, savannas on mesic sites with deep soils rapidly degraded as woody succession followed fire protection and gave rise to closed oak forests (Cottam 1949, McCune and Cottam 1985, White 1994, Anderson and Bowles in press). Consequently, most dry and dry-mesic oak forests and woodlands occurring in the eastern prairie-forest transition today were derived from savannas. In some cases, the derivation of oak forests/woodland from savanna is indicated by the presence of large open-grown trees surrounded by smaller forest-grown trees whose origin dates to the time of European settlement and fire protection. Similarly, oak trees with multiple stems that arise from a large root crown often originated from oak grubs and provide evidence of the former occurrence of savanna on a site (Cottam 1949, Curtis 1959). On some sites overgrazing by domestic cattle nearly or completely eliminated understory vegetation, while agriculture and urbanization fragmented and destroyed remnants. Thus, few, if any, intact savannas survive on deep silt-loam soils in the Midwest (Curtis 1959, Madany 1981, Apfelbaum and Haney 1991, Packard 1991, Anderson and Bowles in press). Nuzzo (1986) estimated that there were about 12 million ha of original tallgrass savanna in the Midwest, of which only 0.02% (2,607 ha) remained.

Dry Savannas

Successional processes that would convert savanna to woodland and forest proceed at a slower rate on xeric sites than mesic ones. Additionally, agricultural development generally results in lower returns on xeric savannas than on mesic ones so less development tends to occur on xeric savannas. Consequently, savannas occurring on xeric sites, such as deep sand deposits, or in areas where there are shallow soils over bedrock, have a somewhat larger percentage of the original savanna remaining, albeit in an altered state, than do the mesic savannas (Taft 1997). For example, in pre-European settlement times, jack pine barrens occupied about 20,000 km^2 in northern Michigan, Minnesota, and Wisconsin. Of the 920,000 ha of historic pine barrens that occurred in Wisconsin about 3,500 ha or 0.38% of the original barrens remain (Vora 1993, Pregitzer and Sanders in press). Pine barrens were lost through lumbering, agriculture, and conversion to red pine plantations. Successional processes that resulted from fire cessation converted the barrens to closed forests with increased abundance of hardwoods, (e.g., white birch [*Betula papyrifera*]; black cherry [*Prunus* *serotina*], maples [*Acer* spp.], and oaks [*Quercus* spp.]) and red and white pines [*Pinus resinosa* and *P. strobus*]) (Curtis 1959, Vogl 1970, Pregitzer and Sanders in press). Nevertheless, the potential to restore substantial areas of these barrens to historic conditions remains.

Historic jack pine barrens had tree densities less than 49/ha (20 trees/acre) with the dominant trees in the historic barrens being jack pine and Hill's oak. The patchy environment in the understory, which varies from open areas to closed canopy conditions, creates habitat for an unusual ground layer vegetation. The flora includes sand prairie and northern forest forbs, graminoids such as big and little bluestems (*Andropogon gerardii* and *Schizachyrium scoparium*), wild mountain rice *(Oryzopsis asperifolia),* poverty grass *(Danthonia spicata),* and sedges with Pennsylvania sedge *(Carex pensylvanica)* often being prominent. Important shrubs on pine barrens are blueberries *(Vaccinium angustifolia)* and sweet fern *(Comptonia peregrina)* (Curtis 1959, Pregitzer and Sanders in press).

Ecosystem Management of Savannas.

In the Midwest, few remnant savannas are sufficiently large to be managed on a landscape scale. An exception may be areas historically occupied by jack pine barrens in the northern lower peninsula of Michigan. In this region, the United States Forest Service and the Michigan Department of Natural Resources manage jack pine plantations to produce wood products and habitat for the federally endangered Kirtland's warbler (Probst and Weinrich 1993). Jack pine plantations are managed on a fifty-year rotation with pines planted in a sine wave pattern to create openings that are utilized by the bird as nesting areas when the plantations are 5 to 20 years in age. The bird's listing as one of the first species protected under the Federal Endangered Species Act was prompted by a precipitous decline in the population of singing males from over 500 in 1961 to approximately 200 in 1971 (Weinrich 1995). Nevertheless, there was a marked increase in the number of male birds singing on territories following a 10,000 ha (24,000 acres) wildfire (Mack Lake) in 1980, with the highest number of males (765) being counted in 1995. The number of singing males declined slightly since 1995, 692 and 728 in 1996 and 1997, respectively, as the area of the Mack Lake burn developed beyond the stage of optimum nesting habitat.

The marked increase in birds following a single large wildfire suggests that designating substantial areas of potential jack pine barrens solely to create habitat for Kirtland's warbler would benefit the bird more than devoting all management areas to multiple-use functions. Fire-return intervals in the historic barrens were in the range of 25–50 years, and burns undoubtedly covered areas that were more extensive than the area of the Mack Lake burn (Curtis 1959, Vogl 1970, Whitney 1986, Pregitzer and Sanders in press). Management that stimulates historic fire regimes would probably benefit the warbler through the restoration of the historic barrens and maintain ecosystem processes to which the bird is adapted. Single species management for endangered species is likely to be less successful than management to restore ecosystem function and structure to the historic landscape to which the species is adapted. Moreover, ecosystem management in units that are sufficiently large to re-establish natural process, such as fire, has the salutary effect of benefiting organisms other than the target species that are also dependent on this ecosystem (Robertson et al. 1997, Taft 1997).

Conclusions

The savannas of the Midwestern United States are of recent development, having originated in the warm, dry, postglacial Hypsithermal period about 8,000 to 3,500 years before present. Savannas are transitional between eastern deciduous forest and tallgrass prairie and contain species from both vegetation types. There is no single definition of savannas, and varied vegetation types are called savannas. However, Midwestern savannas share several features in common. Savannas have a discontinuous tree canopy that is dominated by members of the oak genus *Quercus*. The ground cover often has a high component of species associated with tallgrass prairie, and a majority of the plant diversity occurs in the ground cover. Historic savannas required landscape-scale disturbance (repeated fires) for maintenance of diversity and stability. Most of the historic savannas, especially those on mesic sites, were destroyed at the time of extensive European settlement through agricultural development and cessation of fires that allowed conversion of savannas to closed oak forests. The remaining remnant savannas are small, fragmented, and have experienced loss of species due to fire suppression, grazing by cattle, and invasion of exotic species. Nevertheless, interest in restoring remnant savannas to historic conditions has grown in the past decade, and progress is being made on developing techniques for restoration and understanding the nature of savanna ecosystems (Fralish et al. 1994, Packard and Mutel 1997, Taft 1997, Anderson et al. in press).

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Stephen Budiansky

Some Historical Influences on Modern Views of Nature in America

Abstract *Many widely accepted contemporary views of nature, which emphasize the idea that human interference in ecological processes is invariably harmful, stem from the historical circumstances under which the nature appreciation movement first arose in the late eighteenth and early nineteenth centuries. Nature was romanticized as the embodiment of perfection and a mirror of God, if not the literal dwelling place of God. What moved early nature admirers to seek out "wild places" was precisely the absence of man and the sense of solitude that conferred. This view, which persists today, has led many to ignore or denigrate the significant historical influence that the North American Indians had on their environment through extensive burning of forests and hunting of ungulates; and, further, to adhere to an ahistorical paradigm of strict nature "preservation" that opposes any active management by humans, even for nonexploitive, ecological goals.*

1

Francis Parkman, a great nineteenth-century popularizer of cowboys, Indians, mountain men, and sundry other icons of the romanticized American wild lands, portrayed the ancient forests of the New World as vast, dark, and untrodden. In "the depths of immemorial forests, dim and silent as a cavern," "wrapped in the shadow of the tomb," not a flicker of sunlight ever touched the ground; they were "ancient as the world," to whose "verdant antiquity the pyramids are young." Only where Europeans had intruded was it otherwise. Between the bits of rough civilization the settlers had carved out of the virgin land lay "a broad tract of wilderness, shaggy with primeval woods" (Day 1953). A squirrel, it was said, might in the days before the white man arrived have traveled from Maine to Louisiana never once setting foot on the ground, but leaping from tree to giant tree.

A very different metaphor came to the mind of more than one early explorer who actually set foot in America's "primeval woods." A stagecoach, said one, might be driven from the east coast to St. Louis without first clearing a road. "A man may gallop a horse amongst these woods any waie, but where creekes or Rivers shall hinder," agreed Captain John Smith of the Jamestown, Virginia, settlement. If there is one point on which the early European travelers and settlers who set down their observations of the New World agree, it is that the forests of eastern North America reminded them of nothing so much as the carefully tended parks of the great estates of their homelands. An explorer in 1607 observed the trees around present-day Portland, Maine, "growing a great space asunder one from the other as our parks in England and no thicket growing under them." In the early days of the Plymouth colony the Pilgrims found the woods "thin of Timber in many places, like our Parkes in England." In New Jersey in the mid-seventeenth century, the woods were described as "but thin in most places, and very little Under-wood"; another explorer noted an abundance of high grass and trees that "stand far apart, as if they were planted." In such open, parklike wood, deer and turkey could be seen a mile away, cattle three miles (Martin 1973; Pyne 1982:46–47).

Parkman romantically portrayed the sixteenth century Italian navigator Verrazano lying off the coast of New England espying one of his mighty literary forests, full of "shadows and gloom." Yet Verrazano himself told of marching inland fifteen miles from Narragansett Bay, in what would become Rhode Island, and finding "open plains twenty-five or thirty leagues in extent, entirely free from trees or other hindrances." Where the explorer did encounter forests, they grew so open and unencumbered by underbrush that they "might all be traversed by an army ever so numerous," he marveled (Maxwell 1910, Day 1953).

The Europeans marveled at these open woods and meadows, but they did not have to search far for an explanation. If the land reminded them of carefully tended parks at home it was for a good reason. One of the earliest explanations was set down in 1632 by Thomas Morton, an English fur trader and adventurer who traveled the backwoods of eastern central Massachusetts and settled in what is now Quincy, Massachusetts. (He did not remain long. A free-thinker, he was always in trouble with the local authorities. After being repeatedly arrested, he was finally expelled for licentiousness, selling firearms to the Indians, and penning a satiric tract against the Puritans). Morton was a keen observer, and his travels off the beaten path gave him a first-hand knowledge of the ways of the Indians. He explained that it was deliberate management by the native inhabitants that kept the woods as they were:

> The Salvages [sic] are accustomed to set fire of the country in all places where they come; and to burn it, twize a yeare, vixe, at the Spring, and at the fall of the leafe. . . . The burning of the grasse destroyes the underwoods, and so scorcheth the elder trees, that it shrinks them, and hinders their growth very much. . . . And this custome of firing the country is the means to make it passable, and by that meanes the trees growe here and there as in our parks: and makes the country very beautifull, and commodious. (Bromley 1935)

The practice appears to have been extremely widespread. In Virginia, through a combination of burning and fuel-wood cutting, the Indians had managed to clear some thirty or forty acres of land per capita at the time the first Europeans arrived; three centuries later, although the total area cleared was obviously much greater, it amounted to considerably less per capita—only six or seven acres of treeless land per person. The dominant nineteenth and early twentieth century view that the Indians were ragged bands of backward savages incapable of having any significant impact on the land—and the more recent view that they were intuitive ecologists whose religious respect for nature forbade them to tamper with it—is certainly called into question by the testimony of the early settlers.

Of course along with the open woodlands and meadows there were certainly stands of denser, older forest; the landscape was a shifting mosaic through time and space, the product of many competing forces. But the accounts of early travelers and other evidence suggests that Indian-set fires had a major effect in shifting the balance toward younger stands on a very broad scale. An analysis of early land surveys concluded that at the time the European settlers arrived in the Pacific Northwest in the nineteenth century, stands older than 200 years occupied only about 5 percent of southwest Oregon—hardly the "sea of old growth" that modern environmental activists claim once existed (Zybach 1994). Even supposedly uninhabited regions were frequented regularly by Indian war or hunting parties that left their mark. In southwestern Virginia William Byrd reported seeing the sky filled with smoke so dense that it blocked out the mountains. "This happened not from haziness of the sky," he said, "but from the firing of the woods by the Indians, for we were now near the route the northern savages take when they go to war with the Catawbas and other southern nations. On their way, the fires they make in their camps are left burning, which catching the dry leaves which lie near, soon put the adjacent woods in a flame" (Maxwell 1953). Other travelers reported finding vast, open savannas far inland from the heavily occupied eastern seaboard; the only trees that they found growing there were confined to low swamps or wet areas along streams, which escaped the flames. Fire scars left in the annual growth rings of old trees in New Jersey confirm the settlers' observations, testifying to fires every ten to fifteen years (Little 1974). Careful studies of the fire history of the Rocky Mountains offer convincing evidence for frequent Indian-set fires in that region, too. When tree rings of old-growth stands in western Montana were analyzed, it became clear that fires were much more frequent (once every nine years) in areas that had been heavily used by Indians, as compared to similar but more remote sites (every 18 years). And more frequent burning had major ecological implications: Stands that burn every seven years or so are dominated by tall ponderosa pines and a grassy undergrowth. Older stands, by contrast, become rapidly clogged with woody shrubs, an understory of shade-tolerant Douglas fir, and a build-up of insect and disease pests (Barrett and Arno 1982).

Perhaps the most telling evidence for the dominant role that Indian-set fires played in shaping the American landscape is what happened when the Indians were pushed off the land. One early Massachusetts settler observed that "in some places where the *Indians* dyed of the Plague some foureteene yeares agoe, is much underwood . . . because it hath not been burned" (Thompson and Smith 1970:259). One of the great ironies in the myth of the forest primeval is that the dense, thick woods that later settlers did indeed encounter and arduously cleared were not remnants of the "forest primeval" at all. They were the recent, tangled second growth that sprung up on once-cleared Indian lands only after the Indians had been killed or evicted and the Europeans began to suppress fire. What later settlers took for the forest primeval was in fact much closer to being an abandoned ranch. "The virgin forest was not encountered in the sixteenth and seventeenth centuries," writes one historian; "it was invented in the late eighteenth and early nineteenth centuries" (Pyne 1982:46–47).

2

What, then, explains this late-eighteenth and early-nineteenth century urge to revise this history, to romanticize nature, to reinvent the American landscape as a virgin wildland and the Indians as ecological saints who trod softly on moccasined feet without snapping a twig?

The admiration for nature that has emerged as a prominent and broadly accepted feature of Western culture over the last 200 years or so finds little counterpart in the previous 2,000 years of Western civilization. Cultural beliefs of course rarely spring into existence fully formed; it is almost always possible to find hints and foreshadowings of any era's characteristic sentiments, beliefs, and ideologies; indeed it is not uncommon to find certain beliefs and their antitheses coexisting for thousands of years, with one or the other predominating at different times. There is much enthusiasm among environmentalists today for tracing a human love of nature even to our genes—it is, we are told, a "biophilia" that reflects an evolutionary adaptation of stone age man. Maybe so, and likewise perhaps a love of freedom is in our genes, too. But that tells us nothing about why American democracy arose when it did after centuries in which kings and despots reigned. Similarly, however ancient the roots of modern affinity for nature may be, the fact remains that for most of recorded history, the *dominant* mode of feeling toward nature expressed in Western civilization was one of hostility. Before the end of the eighteenth century, mountains, when they were commented upon at all, were generally described with abhorrence. They were "warts," "wens," "the rubbish of creation." Dr. Johnson, in 1738, expressed the opinion that the Scottish hills "had been dismissed by nature from her care." Other seventeenth and early eighteenth century writers were hardly less sparing in their censure of mountains: The Alps were "high and hideous," "monstrous excrescences of nature," the place where nature had "swept up the rubbish of the earth to clear the plains of Lombardy." An early visitor to Pike's Peak wrote, "The dreariness of the desolate peak itself scarcely dissipates the dismal spell, for you stand in a confusion of dull stones piled upon each other in odious ugliness" (Rees 1975).

The very word *wilderness* was a term of clear disapprobation. It meant an unimproved wasteland, a place devoid of value, a place to be shunned and hurried through. Mountains were places of wolves, bears, bandits, bad roads, and violent and unpredictable weather. The North American forests harbored wild animals and hostile Indians. To a farmer who needed to clear fields to feed his family and graze his livestock, the woods were a back-breaking obstacle; felling trees and pulling stumps was the most arduous job a settler faced.

In Medieval Europe, affection for nature carried with it the further suspicion of sacrilege; axe-wielding monks leveled forests to extirpate sacred groves or other sites of pagan nature-worship (Oelschlaeger 1991:70–72). Landing at Plymouth, William Bradford beheld the New World—and called it "a hideous & desolate wilderness, full of wild beasts & wild men." The forests of New England were a "howling" and "dismal" place, gloomy and sinister, full of evils real and spiritual. In 1653 the English historian Edward Johnson described the forests of North America as a "remote, rocky, barren, bushy, wild-woody wilderness," and he was not being complimentary (Cronon 1983:5).

So, again, what explains the great change of heart between the eighteenth century and now? How did nature change from a place of chaos, ugliness, and evil to one of order, harmony, and beauty?

Rarely has there been such an abrupt and sweeping transformation in dominant social attitudes. Yet in its very abruptness lies the explanation of how an ecologically unsubstantiated and ahistorical belief in nature as perfect, orderly, harmonious, and separate from man came to be virtually synonymous with a love for nature, and why even today this special vision of the natural world holds such a grip upon us. Nature—or at least the Arcadian vision of nature as a place of towering, ancient woods, majestic beasts, and timeless hills, a place where man may enter only as an intruder, observer, or worshipper—was an invention of the imagination of man. To love nature, man first had to invent a nature worth loving. And in inventing nature he perhaps inevitably consulted the romantic yearnings of his soul, not the miserable experience of thousands of years of grim reality. It was "the literary gentleman wielding a pen, not the pioneer with an axe" who could afford to romanticize nature (Nash 1982:44).

For the early nature appreciation movement was both self-conscious and self-consciously elitist. Those eighteenth century aristocrats—for aristocrats they almost exclusively were—who suddenly and unexpectedly began to express an admiration of mountains and other natural scenery were explicit in their belief that the ability to appreciate such beauty was not innate, but acquired. Nature was something that only the cultivated, trained through an appreciation of fine painting and landscape gardening, could truly understand and value. It was a sort of connoisseurship; one could no more expect a ploughman to properly appreciate the Alps than one could expect him to appreciate a glass of fine old port. As late as 1844, the poet William Wordsworth was complaining in a letter to an English newspaper about a proposed railroad that was to be built to the Lake District. His concern was not, as a modern-day preservationist might expect, that the railroad itself would mar the countryside; the problem was rather that it would bring trainloads of untutored sightseers who were not equipped to value what they were seeing. "The perception of what has acquired the name of picturesque and romantic scenery," he sniffed, "is so far from being intuitive that it can be produced only by a slow and gradual process of culture" (Rees 1975).

The tastes of the aristocratic nature lovers of the eighteenth and nineteenth centuries were perfectly revealed in the English landscape movement, which rejected the tame, artificial symmetry and formality of traditional gardens in favor of the wild and "natural." But the flowing landscapes that replaced the rigid lines of trees in pots and clipped hedges were an invented nature, an aesthete's nature. Every curve and vista was calculated to offer "insights" and "subjects of meditation"; streams were dammed to form poetic lakes, trees were set in artful clumps, and garden buildings were pressed into service as moral or philosophical allegories. There was a great truck in Classical and Gothic ruins, real and synthetic. "English landscape was invented by gardeners imitating foreign painters who were invoking classical authors," mocks the character Hannah in Tom Stoppard's play "Arcadia," and she has it about right (Stoppard 1993:25).

The carefully crafted landscapes of ruined abbeys, jagged cliffs, unkempt trees ("everything but vampires," Hannah says) betrayed a motive that beclouds our thoughts about nature to this day. The natural world's ability to stir the soul, even fill it with terror, was the prime attraction. This was nature as escapism—the place that "can stir you up as you were made to be stirred up," as the Sierra Club's David Brower would still describe it two centuries later (Hamilton 1994). Much the same taste accounted for the popularity of the Gothic novel; indeed the English landscape garden was almost a Gothic novel come to life, in crags and unkempt trees and "druidical" huts. The eighteenth century English landscape architect William Kent went so far as to plant dead trees in Kensington Gardens "to give a greater air of truth to the scene." The idea was to create a garden that looked old, as if it had been neglected for centuries. In a few particularly wonderful instances the Gothic touches went completely over the top. The owner of Pain's Hill in Surrey had a hermitage, complete with resident hermit, installed on his redone grounds. The hermit signed a seven-year contract at £700; he was supplied food, hassock, and hourglass, and undertook not to cut his hair, beard, or nails and to eschew speech. It was perhaps only inevitable that he was caught sneaking down to the pub after just three weeks on the job (Elliott 1994; Johnson 1979:226–27).

By the end of the eighteenth century, the well-to-do English seekers of soul-stirring experience were beginning to venture forth from their libraries and gardens into the genuine "wilderness," too. They were doing what seems perfectly commonplace now, but what was an exceptional departure then. English tourists began visiting Scotland and its wild hills in significant numbers only around 1810; it was in 1818 that the first English-language guidebook to Switzerland and the Alps was published. The motive of these pioneering nature tourists was virtually indistinguishable from that of the landscape gardeners. In expressing a love of the natural world, both were expressing a hunger for heightened experience, and it was only a very particular and idealized conception of nature that could fit that bill—a nature vast, ancient, eternal, separate, and awe-inspiring, a nature that at least presented the illusion of being beyond the touch of man. Such a wilderness proved the "ideal stage for the Romantic individual to exercise the cult that he frequently made of his own soul," as the historian Roderick Nash put it. But it is telling that these connoisseurs of the "sublime"—an odd word that came to be used at the time to express the contradictory emotion of fear and thrill (the notion also crops up in a predilection for deliberately contradictory phrases such as "delightful horror," "terrible joy")—were as apt to visit coal mines and quarries as mountains to satisfy this penchant (Rees 1975; Worster 1977:81–83; Nash 1982:47).

Again, we are dealing with degrees, not absolutes. Not all of the early environmentalists were aristocrats; John Muir notably was of humble origins. But if one looks through the rolls of the nature preservation societies in Britain and America in the nineteenth century the pattern is undeniable (Lowe and Goyder 1983, Bramwell 1989).

3

Indians only fit into the romantic picture of a wild, untouched wilderness to the extent that they could be seen as creatures of nature themselves, living in perfect harmony with nature's harmonious perfection. Many modern-day nature lovers assiduously perpetuate the myth of the noble savage in parallel to the myth of pristine nature. Ancient hunter-gatherers, who lived in a state of "balanced and harmonious" existence, altering "neither the natural firmament nor the animals and plants that share the land with them," were the original lovers and worshipers of nature, writes the environmental historian and philosopher Max Oelschlaeger, for one (Oelschlaeger 1991:34).

Yet ecological and archaeological evidence strongly suggests not only that Indians practiced landscape management on a truly heroic scale with the use of fire, but also that they were perfectly capable of drastically altering the size and distribution of ungulate populations, and even hunting a number of species to extinction (Kay 1994). Estimates of the pre-Columbian population of America are notoriously uncertain, but credible calculations place the number of people living north of the Rio Grande as high as 12 million (Dobyns 1966, Denevan 1992). Far from being a small band of harmonious stewards of the land, they dramatically modified their environment. Camels, woodland musk oxen, mammoths, mastodons, stagmoose all vanished shortly after the first major occupation of North America by man, 12,000 years ago. All were species that had evolved for a million years in North America in the absence of human hunters; the species that survived, by contrast (moose, elk, caribou, deer), were all recent arrivals from Asia and whose evolutionary history included defensive adaptations to human predation (Pielou 1991:254–57).

The determination to ignore such uncomfortable facts and to idealize the Indians as precocious environmentalists remains strong and may explain the credulity with which many have accepted and propagated the now-famous speech of Chief Seattle, a nineteenth-century American Indian whose prophetic warnings of the coming ecological crisis first came to wide public attention when they were used to narrate a 1972 television movie about pollution, called *Home.* "This we know—the earth does not belong to man, man belongs to the earth," the chief declares in one of the many versions of the speech that were subsequently reprinted. "All things are connected like the blood which unites one family. Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself."

To a few experts on American Indians, this all smelled a bit fishy. The real Chief Seattle did make a speech in about 1855, which was recounted thirty years later in a newspaper article by an American who had been in the audience; but according to this account, Seattle merely praised the generosity of the "great white chief" for buying his lands and offered not a word of ecological insight. (Seattle was also known to historians for his dignified refusal to allow the grateful white settlers to name their town after him; he objected that his eternal sleep would be interrupted each time a mortal uttered his name. The objection vanished when the whites proposed levying a small tax on themselves to provide the chief with some advance compensation for his troubles in the hereafter.) Nowhere was there any record of Seattle as a prophet of environmentalism.

A little research eventually cleared up the mystery. The reason Chief Seattle's speech sounded remarkably like the words of a twentieth-century, white, middle-class environmentalist, it turned out, was because they were the words of a twentieth-century, white, middle-class environmentalist. Ted Perry, a professor of film at the University of Texas at Austin, had written the script for the movie and had never claimed that the words he put in Chief Seattle's mouth were anything but fiction. But the truth has never quite managed to catch up, and even though the spuriousness of Chief Seattle's speech has been widely publicized, Seattle's anachronistic warnings about the fragile balance of nature *continue* to be reprinted and quoted in environmental magazines, sermons from the pulpit, classroom study kits, posters, textbooks, and bumper stickers. As a seemingly far-seeing anticipation of the central credo of modern environmentalism by a representative of an ancient way of life, Chief Seattle's speech has attained the status of what one admiring environmentalist thinker—Theodore Roszak, a professor of history at California State University—has called "a piece of folklore in the making, a literary artifact mingling traditional culture with contemporary aspiration." Roszak is aware that the speech is a twentieth-century concoction, and admits that he "initially had some scholarly qualms about citing the chief" in his writings, but decided to go ahead anyway: Seattle's "semilegendary" words, Roszak explained, "have become precious to the environmental movement" (Murray 1993; Roszak 1993:50,338–39).

4

There was another force that played a role of great importance in converting new followers to a love of nature in the late eighteenth and early nineteenth centuries, and that was religion. Petrarch climbed a mountain in 1336 and found himself "abashed" at taking pleasure in nature, fearing that to do so was sacrilege. Five centuries later the American theologian Jonathan Edwards proposed a different solution to the conflict between God and nature. Admiring nature was permissible, even admirable, he argued, precisely because nature was "God speaking to us." The feeling of sublime terror inspired by wilderness was a reminder of God's power and wrath. Even the dirt that covers everything and "which tends to defile the feet of the traveler" is a salutary moral lesson from God, a reminder that "the world is full of that which tends to defile the soul" (Albanese 1990:43–45). Others were less explicit about the precise moral lessons of nature and began to suggest simply that sublime landscapes were suitable objects of contemplation as stirring reminders of God's magnificence and grandeur.

This was a significant departure from the recent Puritan past. The wild and terrible in nature was no longer the rubbish left over from the creation or the unenlightened province of the devil. It was a testimonial to the greatness of God. Climbing a mountain was no longer an act of sacrilege, but an act of moral instruction.

If it was not yet an act of worship, that was coming. To Henry David Thoreau, nature's value was above all what it would do for man's soul. "I derive more of my subsistence from the swamps which surround my native town than from the cultivated gardens in the village," he wrote. "My spirits infallibly rise in proportion to the outward dreariness. . . . When I would recreate myself, I seek the darkest wood, the thickest and most interminable and, to the citizen, most dismal swamp. I enter a swamp as a sacred place, — a sanctum sanctorum." His motive was a "desire to bathe my head in atmospheres unknown to my feet" (Emerson and Thoreau 1991:94–100).

For Thoreau, nature's chief value was that it was not the town. The woods were an escape from social corruption, or, more to the point, people. "Society is always diseased, and the best is the most so," he wrote in *The Natural History of Massachusetts.* The conventions of social intercourse were stultifying. "Politics . . . are but as the cigar-smoke of a man." Commerce was frivolous. Labor was degrading, farming no better than serfdom. Even man's amusements were nothing but a sign of the depths of his despair. "The greater part of what my neighbors call good I believe in my soul to be bad." The word *village,* he said, comes from the same Latin root as *vile* and *villain,* which "suggests what kind of degeneracy villagers are liable to." Thoreau wanted to "shake off the village," where men spent empty, monotonous, vacuous, and spiritually impoverished lives. "I confess that I am astonished at the power of endurance, to say nothing of the moral insensibility, of my neighbors who confine themselves to shops and offices the whole day for weeks and months, aye, and years almost together," he wrote. It was the freedom that nature had to offer that was its chief attraction. Thoreau went to live at Walden Pond, he said, "to transact some private business with the fewest obstacles."

If nature's value rested upon its being a spiritual refuge from the evils of society, then nature, by definition, meant its separation from man and the absence of man. It was the very fact that man and all his follies were *not* to be found there that made nature estimable. What Thoreau disliked about man's presence was not that it would interfere with or degrade critical biological processes; what he disliked about man's presence was its presence. Thoreau likewise disapproved of wealth, church, rules, voting, dinner parties, and young men not as smart as he who sought to join him on his walks. He would tell the latter that he "had no walks to throw away on company" (Emerson 1862, Stevenson 1880). The link between environmentalism and escapism is an enduring one, and Thoreau's admiration of the wild as a place to turn one's back on the town can be heard in the words of David Brower, Bill McKibben, and other nature writers of our day.

Thoreau's declaration that "in wilderness is the preservation of the world" is one of the most quoted in modern environmental writing. Time and again it is cited in an utterly anachronistic fashion, however, wrenched from the clearly spiritual context of the passage in which it appears. When Thoreau was talking about "the preservation of the world," he did not mean the physical or ecological world at all, but rather the spiritual world of man. Those who cite this passage to lend authority to modern calls for preserving tropical biodiversity are misunderstanding what Thoreau was saying.

Thoreau's spiritual aversion to society readily explains some of the appeal that the woods held for him. But nature's stock was rising at this time for other fundamentally spiritual reasons, too. Many of the early American nature worshippers, including Thoreau's fellow townsmen in Concord, Ralph Waldo Emerson and Asa Bronson Alcott, were deeply involved in many reform-minded causes—temperance, abolition of slavery, dietary reform, alternative medicine—that were seen by their adherents quite explicitly as a moral and spiritual rejection of artificial evils and a return to the uncorrupted purity of nature. Just as "natural law" had shown Americans the falseness of monarchy, slavery, and other political systems that denied men their God-given rights, so natural foods and natural healing would show the falseness of alcohol and artificial medicines that denied men their God-given health. Rather than try to rise above nature and the "brute" or "animal" instincts, as Christianity had so long seemed to urge, the message of these "Christian physiologists" was that man must give up the sinful luxuries and excesses of civilization and return to nature (Albanese 1990:130–42; Furnas 1969:441–42).

The point is not to suggest that nature

lovers were cranks (though some certainly were). But it is crucial to recognize that the impulse that gave rise to such feelings for nature was fundamentally spiritual, not ecological. To these pioneering nature enthusiasts nature was but a means to an end. The spiritual ends they saw in nature were the *justification* for paying attention to nature at all. They were spiritual pilgrims first, birdwatchers second. And this attitude further drove home the conviction that nature—defined explicitly for this purpose as the world uncorrupted by man's artificial evils—embodied God's perfection. Thoreau was surely tongue-in-cheek when he and a few fellow drop-outs from Concord society formed the "Walden Pond Society" as an alternative church for Sunday morning meetings and proposed plucking and eating wild huckleberries as a substitute for the more conventional sacrament of communion. But there was no hint of irony in Emerson's transcendental conviction that nature was the literal dwelling place of God: "The aspect of nature is devout. Like the figure of Jesus, she stands with bended head, and hands folded upon the breast. The happiest man is he who learns from nature the lesson of worship." Emerson believed that nature was both a source of moral instruction and discipline, and the holy of holies where man would become "part or particle of God" himself (Emerson and Thoreau 1991:53,63–64; Alcott 1872:42).

5

Such feelings toward nature are real and earnest and genuine. Thoreau and Emerson and later, John Muir, struck a deep chord that resonates yet. Those who fight for more wilderness areas these days will speak of experiencing a sense of connection with something greater than themselves, something "primeval, threatening, and free of jarring reminders of civilization" (Mardon 1993).

Satisfying human needs, including a need for spiritual solitude, is a valid end. But what is good for the soul is not always what is good for nature. Some ecological goals are consistent with a goal of wilderness-as-solitude, but many are not. Setting a goal of providing the experience of solitude tells us nothing about what measures might be required to manage an ecosystem effectively to preserve endangered species, to reestablish disturbance processes that have been lost or suppressed by the advance of civilization, to restore vanished ecosystems such as the midwest oak savannas, to counter the effect of exotics, or to keep ungulate populations within the range of historical variation that had obtained since the end of the Ice Age—under the influence of heavy human predation—until the genocide of the Indians and preservationist policies allowed their numbers to explode.

Of course there has long been a wide spectrum of thought within the conservation and environmental movements, and paralleling the nature religion of Thoreau and Muir there early on arose a scientific and practical strand of thought represented by Theodore Roosevelt, Gifford Pinchot, and Aldo Leopold to name but a few. Many environmentalists and conservation biologists insist that environmentalism today has moved beyond romantic sentiment and simplistic formulations about the "balance of nature"; they insist that romanticism plays little part in modern, scientifically based advocacy for wilderness (Waller 1996). Unfortunately, one does not have to search very hard to find simplistic, romantic notions aplenty in contemporary debates over wilderness. Fundraising literature from mainstream environmental groups regularly invokes the theme that human intrusion is wrong and unnecessary, that wilderness is a sacred concept, that excluding "jarring reminders of civilization" is indeed what it is all about. The "balance of nature" idea and simplistic, deterministic notions of succession and climax may be a dead letter among scientists, but it is very much alive among influential nature writers of our day. The environmental historian Donald Worster, for example, claims not only that nature literally *has* a set order and purpose that mankind has a moral duty not to interfere with; he goes on to make the purely political argument that scientists who point out the simplistic myths embodied in the notion of wilderness or the inherent balance of nature should not do so because they are thereby abetting "members of the Farm Bureau" and other such "fierce private property and marketplace advocates" who lack a proper "ethic of environmental restraint and responsibility" (Worster 1997). Worster elsewhere insists that ecologists must, on moral grounds, adhere to concepts such as climax and succession (which he sees as under siege by modern "permissive"—his word—concepts such as disturbance and patch dynamics) because to abandon "climax ecology" "would be to remove ecology as a scientific check on man's aggrandizing growth" (Worster 1993; Worster 1977: ix–x, 240–42). The environmental writer Bill McKibben writes that man's intrusion in nature destroys its very meaning, which is its "independence" (McKibben 1989:70,73,104). Others have criticized even ecological restoration on similar grounds, arguing that the value of nature rests solely and completely in its freedom from "the domination of human technological practice" (Katz 1992).

Such thinking has had very real effects on contemporary public debate and public policy. Land managers who have attempted to institute prescribed burns, carry out salvage logging to reduce fuel buildup, or, most controversially, cull ungulates can testify that nature romanticism is a force that is alive and well, with a vengeance. Even in large parks, forests, and wilderness areas, explosions of ungulate populations have wreaked havoc on rare songbird species, on endangered plant populations, and on forest regeneration, yet attempts to limit their numbers have been repeatedly met by opposition from environmental groups decrying any "intrusion" into nature—and such views increasingly prevail (McLaughlin 1993, Maryland Cooperative Extension Service 1994).

But even a number of prominent scientists who advocate expanded wilderness areas on purportedly scientific grounds frequently invoke romantic arguments to justify their position. The so-called "Wildlands Project," an audacious proposal to convert as much as half the land area of large regions of the United States into protected wilderness, is based on a scientific analysis of land areas required to sustain minimum viable populations; yet these analyses contain huge uncertainties, and Michael Soulé, a biologist and project founder, has been quoted as defending the project's basis and aims in explicitly spiritual terms—as providing people with the experience of "wildness," "bigness," and "fierceness" (Mann and Plummer 1993).

Likewise, Edward O. Wilson argues that biodiversity needs to be protected because it is critical for the human soul—that mankind supposedly has an instinctive need to bond with the rest of creation (Wilson 1991:350; Kellert and Wilson 1993). Indeed, a number of writers have recently argued quite explicitly that spiritual feelings of peace and solitude in undeveloped wilderness are *the* prime case for protecting biodiversity; indeed, that such spiritual feelings are one and the same with the scientific case for preserving biodiversity. Stephen Kellert, for example, equates his feelings of solitude and escape from civilization during a walk in the woods with a feeling of "intimate affiliation with living diversity." (Kellert, 1996). Part of why this is so unconvincing is that the feelings these writers describe in such rich Thoreauvian prose have everything to do with the romantic yearning for solitude and essentially nothing to do with any actual feelings that people might be able to summon up for the insects, bacteria, fungi, parasites, and other interesting life forms that make up the overwhelming bulk of "living diversity."

There are many valid and important ecological goals which require management practices that simply will not sit well with those who nurture the romantic yearning for "unspoiled" wilderness. Some of these management practices are ugly and intrusive and violent. Some of the important scientific goals of ecological management are simply not going to evoke feelings of reverence and "intimate affiliation" with nature. I personally believe that protecting even very ugly endangered species is an important goal, and would hate to have to rely on romantic or religious impulses to support it. As some astute critics have pointed out, there is a very grave danger of confusing goals here. Cloaking what is fundamentally a political, sentimental, or religious position in modern scientific trappings is ultimately corrupting to science (Cronon 1995).

A more pressing problem is that a goal of "protecting biodiversity" or creating "wildlands" tells us no more about how to set realistic ecological priorities than does a goal of providing people with opportunities to experience solitude. Wilson's "theory of island biogeography," a simple formula relating species diversity to land area, has been strongly criticized both for its biological infidelity and mathematical naiveté (Connor and McCoy 1979, Heywood and Stuart 1992, Budiansky 1994) and for diverting attention from the studies that are actually needed to help identify biodiversity hotspots and to set priorities. A significant point is that areas that people value for their "wildness" often do not correspond well with biodiversity hotspots. Nor has a clear scientific case been made that vast contiguous "wilderness" areas are always required for preserving biodiversity effectively (Mann and Plummer 1995). Daniel Simberloff, a former student of Wilson's who has conducted extensive research on this subject, has written: "It is sad that the unwarranted focus on island biogeography has detracted from the main task of refuge planners, determining what habitats are important and how to maintain them." (Simberloff 1992). Indeed, the only specific recommendation that Wilson derives from his species-area analyses is a proposal to halt "all" further development of land in the world (Ehrlich and Wilson 1991).

This seems unlikely to happen. In the United States, which can afford to set aside far more land than arguably any country in the world, about 5 percent of land is in parks and wilderness areas; about 70 percent is in pasture, cropland, and producing forests (Waggoner, Ausubel, and Wernick 1996). Even under the most optimistic population control scenarios, world population is likely to reach about 10 billion sometime in the next century before leveling off (Bongaarts 1994). It seems clear that achieving the ecological ends that are widely shared today—such as preserving endangered species—will require active management of many land area that do not fit the definition of "wilderness."

Far from being compatible with the scientific demands of ecological management, the tenaciously lingering romanticism toward nature is often at odds with what is needed. True, if we could set aside half the United States as "wildlands," size alone could accomplish a lot—it could allow for the establishment of large metapopulations, capture natural disturbance processes on a broader scale, and provide needed habitat for certain endangered species such as grizzly bears and wolves that need large individual ranges. But even then there would be problems that would demand active human intervention if our ecological goals are to be met. Disturbance processes upon which many species depend have been curtailed, if not within parks or wilderness areas, then in surrounding areas. Exotic species have intruded. Animals' migration routes have been cut. And the part played by humans for ecologically significant timespans would still be eliminated from such "wild lands." To have a "functioning ecosystem," we would have to make it happen. Intrusion is ecologically sound policy; "wilderness" is not.

Yet the resilience of an artificial view of wilderness, with its deep historical roots, may well explain why "hands-on" management of ecosystems, even for the purest and noblest of environmental ends, so often meets harsh resistance from those who equate any intrusion of man with sacrilege against the credo of nature's perfection, its unity, and its symbolic value as a critique of the shortcomings of human society.

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Vegetation Changes Associated with Oak Wilt in a Wisconsin Sand Savanna

Abstract *This study evaluates the effects of oak wilt, a disease caused by the fungus* Ceratocystis fagacearum *on plant species abundance, composition, and structure in degraded oak barrens at Necedah National Wildlife Refuge. Open patches created by oak wilt are compared to degraded barrens immediately surrounding each patch. Patches are also compared to Old Barrens, a savanna community in the Refuge that has remained open since a wildfire in 1936. Two soil associations predominate in the study area: the better drained Plainfield-Friendship association supported significantly more patches and more prairie/savanna species than the poorly drained Meehan-Newson soils. As predicted, more prairie/savanna species occurred in patches than surrounding woods, but far more occurred in Old Barrens than in patches when comparing within the same soil type. Total herbaceous cover was higher in patches than Old Barrens, and deciduous shrub cover was higher in Old Barrens than in patches; total herbaceous cover was also higher in patches than in woods. Total deciduous and coniferous tree cover was lower in patches than woods, although significant only when comparing patches to woods on Plainfield-Friendship soil. Total herbaceous cover was negatively correlated to total tree cover.*

The dependence of savanna ecosystems on disturbance is well known (Curtis 1959, Anderson 1982, Nuzzo 1986, Haney and Apfelbaum 1991, Skarpe 1992, Heikens and Robertson 1994, Huston 1994). Fire effects, the primary disturbance associated with savannas, have been studied extensively. Fire reduces the litter layer and canopy cover by killing shrubs and small trees, thereby allowing more light to reach the ground (Dyksterhuis 1957, Daubenmire 1968, White

1983, Hulbert 1986, Skarpe 1992, Huston 1994). Warmer soil temperatures and increased light, in turn, encourage the germination and growth of fire-adapted and shade-intolerant species (Daubenmire 1968, Tester 1989, Huston 1994).

Depending upon intensity and the initial successional stage of the savanna, grazing, in conjunction with fire, also discourages the invasion of woody species and alters species composition in favor of those characteristic of open sites (Dyksterhuis 1957, Daubenmire 1968, Anderson 1982, Dyer et al. 1982). Effects of other forms of herbivory, particularly by insects and soil fauna, have yet to be studied (McPherson 1993). While the ecological role of disease, in general, is poorly understood (Burdon 1994, Castello et al. 1995), the localized, host-specific impact of oak wilt is well documented (Gibbs and French 1980, Menges and Loucks 1984, Webber and Gibbs 1989).

Ceratocystis fagacearum, the fungus that causes oak wilt, was first identified in Wisconsin over a century ago (Warder 1881). The principle long-distance vector of the fungus is the picnic beetle (Coleoptera: Nitidulidae) (Buchanan 1960, Gibbs and French 1980, Webber and Gibbs 1989, Bruhn and Heyd 1992), which is attracted to wounded but otherwise healthy trees. Picnic beetles can transfer spores up to 1 mile from an infected oak (Juzwik 1983 cited in Bruhn and Heyd 1992). Local spread occurs through root grafts (Kuntz and Riker 1961, Bruhn and Heyd 1992), the fusing of the roots resulting in functional vascular connections (Graham and Bormann 1966), and is the primary means of transmission (Gibbs and French 1980). Root grafts account for the patches of dead oaks that characterize an infected area (Worf and Kuntz 1978, Gibbs and French 1980).

The extent of root grafting varies by species and is influenced by soil (Gillespie and True 1959, Graham and Bormann 1966, Bruhn et al. 1991, Bruhn and Heyd 1992). Red oaks (genus *Quercus,* subgenus *Erythrobalanus*), the dominant deciduous trees of oak barrens (Curtis 1959, Whitford and Whitford 1971), are especially prone to root grafting (Worf and Kuntz 1978), and the incidence of root grafts increases on sandy, well-drained soils (Gillespie and True 1959, MacDonald and Hindal 1981, Bruhn and Heyd 1992).

Studies of *C. fagacearum* to date have fallen into two broad categories: epidemiological studies, including the impact of oak wilt on oaks (Henry et al. 1944, Struckmeyer et al. 1954, Buchanan 1960, Kuntz and Riker 1961, Worf and Kuntz 1978, Gibbs and French 1980, Jacobi and MacDonald 1980, MacDonald and Hindal 1981), and models of the spread of the fungus (Menges and Loucks 1984, Menges and Kuntz 1985, Appel et al. 1989, Bruhn et al. 1991).

This paper examines the effect of oak wilt on the vegetation in a successionally advanced oak barrens at Necedah National Wildlife Refuge (NNWR) in west central Wisconsin. Barrens are a type of savanna characterized by stunted trees and coarse or shallow soils (Curtis 1959, Haney and Apfelbaum 1991, Heikens and Robertson 1994). Curtis (1959) described the vegetation of the Central Sands region as pine barrens, a true savanna dominated by scattered, slow-growing oaks, primarily *Quercus ellipsoidalis* and *Q. velutina* and *Pinus banksiana* and *P. resinosa.* Historically, fire, in conjunction with disease and grazing by both ungulates and insects, maintained the unique physiognomy and structure of barrens; fire suppression at NNWR allowed the barrens to develop into mixed oak and pine woodlands.

Speculation about the historical effect of oak wilt as a natural disturbance (Anderson 1982, Warder 1991, Heikens and Robertson 1994) as well as our own observations of structure and the presence of open-site species in oak wilt patches led us to hypothesize that the impact of oak wilt on barrens communities was similar to the effects of fire. We expected to see more savanna forbs in the ground layer of patches than in the woods. We also expected total herbaceous cover in patches to approximate cover in well-maintained barrens and to be higher than in the surrounding woods. *Carex pensylvanica,* a species of open, upland woods, was expected to be the dominant herbaceous species in the woods, and woodland species in general were expected to be less abundant in patches. We also predicted that *Pinus banksiana,* an early successional species, would be more common in the ground, shrub, and tree layers in patches than in the surrounding forest, comparable to open barrens, reasoning that opening the canopy through the loss of oak trees would favor *P. banksiana* regeneration.

Methods

Study Site

The Necedah National Wildlife Refuge is located in the Central Sands region of Wisconsin, in Townships 18-20 North, Ranges 2-3 East. The NNWR was established in 1936 and currently includes 18,211 ha that are managed primarily for biodiversity and recreation. Barrens restoration became a priority in 1993 in response to concern over the federally endangered Karner blue butterfly *(Lycaeides melissa samuelis)* and other rare species. Currently, 227 ha of mixed oak woodland have been restored to savanna by reducing canopy cover in woodlands from about 90% to approximately 50% through tree removal and fire. A total of 1,441 ha is planned for restoration and management as oak and pine savanna.

Oak wilt was first identified at NNWR in 1975, and aerial photographs were taken in 1978 to assess the extent of spread of the fungus. Initial oak wilt research in 1979–1981 focused on methods for controlling the spread of the fungus (J. Walters, unpublished report). No other research was conducted to determine the impact of oak wilt on the NNWR, and we found no published studies of the ecological effects of *C. fagacearum.*

Two associations comprised the majority of soils at our study site. Plainfield-Friendship soils are well drained and located on higher ground, typically a minimum of 1.5 m above the water table (Gundlach et al. 1991, D. Omernik, personal communication). Meehan-Newson soils are poorly drained and occur in lower lying areas. The five soil series form a gradient from well-drained ridges to poorly drained sedge meadows.

Patch Selection and Sampling

Five of the 69 sections comprising NNWR were randomly selected for sampling. Management history of selected sections was researched, and sections were discarded if disturbed since 1968 by events such as fire, logging, or hydrological change. All sections included in the study contained a minimum of seven oak wilt patches, of which at least five were randomly selected for sampling.

Oak wilt patches were identified primarily by the proximity of several dead oak trees, typically in a circular or elliptical pattern. A minimum of three to four adjacent dead oaks were required to qualify an area as a patch. Areas with fewer than three to four dead oaks qualified if wilting leaves were present on at least one of the trees, indicating an active oak wilt site. Ten patches were sampled in the first section to ensure that sufficient data were collected, and six patches were sampled in another section because one patch was extremely small. A total of 31 patches were sampled in May and August 1995 and July 1996.

The center of each selected patch was identified and line transects established along 0, 90, 180 and 270 degree azimuths from the center. Transects began 1 m from the patch center and extended a minimum of 50 m beyond the edge of the patch into the surrounding woods unless vegetation graded into wetlands, pine plantations, or other habitat unsuited for growth of oaks, at which point transects were terminated. Soils were identified for each 10 m segment along each transect.

Percent cover for each species in the ground layer (vegetation < 1 m tall) was estimated using 1 m^2 circular plots centered at 10 m intervals beginning 1 m from the center of the patch. The number of plots varied with the length of each transect. Coarse litter, fine litter, and bare soil were also estimated. Bryophyte and lichen cover was estimated but not evaluated.

Tree (> 1 m tall, > 5 cm dbh) and shrub and small tree (> 1 m tall, < 5 cm dbh) cover were recorded by species for each 10 m segment using a line intercept method (Kent and Coker 1992). Because hybridization of *Quercus ellipsoidalis* and *Q.velutina,* both of which are in the red oak subgenus, was so extensive and rendered the two species virtually indistinguishable (Curtis 1959), these trees were identified as their hybrid, *Q. paleolithicola* (Gleason and Cronquist 1991).

Old Barrens, also located on Plainfield-Friendship soil, is a floristically diverse unit on the Refuge that appears to have been maintained by oak wilt (R. King, personal communication) since a wild fire restored it in 1936. Vegetation at Old Barrens was sampled by Refuge staff in 1995 using a sampling protocol similar to ours. We compared their data to that we collected from oak wilt patches on Plainfield-Friendship soils.

Analysis was conducted at two levels: vegetation in oak wilt patches was compared to the undisturbed woodlands immediately surrounding the patches, and comparisons were made of vegetation on patches occurring on Plainfield-Friendship soils to vegetation on Old Barrens. The distribution of patches and woods across the two soil associations was examined using a chi-square test. Preliminary analysis of vegetation data indicated that even the most common species had skewed distributions; that and uneven sample size led us to compare the abundance of species using the Mann-Whitney U test ($P \leq 0.05$) (Sokal and Rohlf 1981). We used the Spearman correlation coefficient to determine the effect of canopy cover on total herbaceous cover (Sokal and Rohlf 1981). Designation of prairie/savanna species is based on Gleason and Cronquist (1991) and a list compiled by Will-Wolf and Stearns (in press).

Results

Soils

Chi-square tests of the distribution of patches and woods by soil type confirmed ($P \leq 0.0001$) that most oak wilt patches are on Plainfield-Friendship soils. Not only did patches occur with much greater frequency on the better drained soils, they also tended to be larger (not significantly) on average. Patches ranged in size from 22–78 m in diameter (mean = 52 m) on Plainfield-Friendship soils while patches on Meehan-Newson soils averaged 23–63 m in diameter (mean = 40 m).

Structure

Comparisons between Old Barrens and oak wilt patches on Plainfield-Friendship soil of the three strata (total ground, woody sapling and shrub, and tree layers) revealed significant differences in the ground and shrub layers (Table 1). Sedges, primarily *Carex pensylvanica,* were almost twice as abundant in patches as in Old Barrens ($P \leq 0.0012$) whereas grasses were ten-fold more abundant in Old Barrens ($P \leq 0.0004$). Deciduous shrubs were more prevalent in Old Barrens than in patches ($P \leq 0.0214$).

Comparisons of patches with surrounding woods by soil type showed greater structural variation at several levels (Table 2). Significant differences ($P \leq 0.05$) in total cover occurred only in the ground layer, which was greater in patches than in woods. Total forb cover was significantly higher on Meehan-Newson soils, but total graminoid cover was higher on Plainfield-Friendship soils. Sedge cover was consistently higher on Plainfield-Friendship soil, but grass cover, which was low compared to sedges, displayed no clear pattern in distribution across soils or location. Total tree cover ($P \leq 0.0082$) and deciduous tree cover ($P \leq 0.0240$) were both lower in patches than in woods, as expected.

An examination of total ground layer cover as a function of total tree cover verified that herb cover decreased as canopy cover increased ($P \leq 0.001$) (Figure 1). Ground layer cover as a function of canopy cover in Old Barrens and patches on Plainfield-Friendship soil was not significantly different ($P \leq 0.303$).

Individual Species Distribution

Standardized species richness, the average number of species per 10 m transect, was calculated to take into account the varying unit sizes in the oak wilt study area and Old Barrens (Table 3). Standardized richness was significantly higher ($P \leq 0.0003$) in Old Barrens than in patches on Plainfield-Friendship soil; there was no statistical difference between patches and woods on either soil type.

Table 1. Total mean percent cover and standard deviation for growth forms and subsets of growth forms for Old Barrens and patches on Plainfield-Friendship soil.[1]

	Old Barrens		*Patches*	
Growth Form or Subset	*Mean*	*S.D.*	*Mean*	*S.D.*
Total ground layer	<u>83.360</u>	20.408	<u>104.378</u>	45.580
Forbs	20.120	9.166	27.665	25.995
Graminoids	58.480	7.685	67.994	16.138
Sedges	<u>36.080</u>	10.324	<u>65.973</u>	15.731
Grasses	<u>22.400</u>	6.554	<u>2.021</u>	3.143
Woody cover	4.760	4.736	8.720	8.315
Woody sapling and shrub layer	10.760	8.568	4.001	4.976
Coniferous cover	1.000	2.236	1.629	2.324
Deciduous cover	<u>9.760</u>	7.093	<u>2.371</u>	4.798
Tree layer	35.656	38.518	27.862	20.734
Coniferous cover	16.920	20.496	16.126	15.568
Deciduous cover	18.736	28.527	11.736	13.616

[1] Significant differences are underlined.

Table 2. Total percent cover and standard deviation[1], for growth forms and subsets of growth forms by soil and location for oak wilt patches and woods.

	Plainfield-Friendship Soil				*Meehan-Newson Soil*[1]			
	Patches		*Woods*		*Patches*		*Woods*	
Growth Form or Subset	*Mean*[2]	*S.D.*	*Mean*[2]	*S.D.*	*Mean*[2]	*S.D.*	*Mean*[2]	*S.D.*
Total ground layer	104.378^{a}	45.580	75.573^{b}	40.393	103.394^{ab}	61.518	72.821^{b}	48.297
Forbs	27.665^{ac}	25.995	25.693^{a}	20.216	68.281^{b}	40.542	44.569^{c}	30.654
Graminoids	67.994^{a}	16.138	42.401^{b}	17.695	26.366^{b}	19.447	19.632^{c}	19.488
Sedges	65.973^{a}	15.731	41.673^{b}	17.406	26.306^{b}	19.382	17.397^{c}	20289
Grasses	2.021^{a}	3.143	0.728^{ab}	1.286	0.060^{b}	0.134	2.035^{c}	6.558
Ground layer cover	8.720	8.315	7.479	6.676	8.748	7.194	8.620	8.341
Total sapling and shrub layer	4.001	4.976	6.961	11.171	4.324	5.930	16.884	23.268
Coniferous cover	1.629	2.324	1.306	2.209	0.867	1.938	0.358	0.745
Deciduous cover	2.371	4.798	5.655	10.676	3.458	4.152	16.527	23.076
All trees	27.862^{a}	20.734	62.565^{bc}	29.418	45.764^{abc}	27.424	67.410^{b}	40.109
Coniferous trees	16.126	15.568	18.005	15.240	20.364	23.028	24.798	30.870
Deciduous trees	11.736^{a}	13.616	44.560^{b}	25.476	25.400^{ab}	28.219	42.612^{b}	33.744

[1] No significant difference was reported for any species; superscripts were applied without regard to possible significance or insignificance between species on these sites.

[2] Means with the same superscripted letter were not significantly different.

Thirty-seven species had significantly different distributions (Table 4) when patches on Plainfield-Friendship soil were compared to Old Barrens. Of those 37 species, 18 occurred exclusively in Old Barrens and one, *Gaylussacia baccata,* occurred only in the oak wilt patches. With few exceptions, the species listed (Table 4) are common to savannas. Several species, including *Rosa carolina* and *Pteridium aquilinum,* were not reported in Old Barrens, although we have observed them there.

Comparisons of vegetation in patches and woods by soil type revealed significant differences in the abundance of 10 species (Table 5), including *Acer rubrum* in all three strata. Species such as *Andropogon gerardii* and *Pinus banksiana* occurred exclusively on Plainfield-Friendship soil. *Carex pensylvanica* was more abundant on Plainfield-Friendship soil and in patches; *Andropogon scoparius, Achillea millefolium, Koeleria cristata, Helianthemum canadense, Poa pratensis, Sorghastrum nutans,* and *Solidago* spp., whose distributions were not significantly different, nonetheless, were more abundant in the well-drained Plainfield-Friendship soil. *Gaylussacia baccata* was more abundant on Meehan-Newson soil and significantly more abundant ($P \leq 0.0043$) in the patches than the woods on that soil type. *Pteridium aquilinum* also was more abundant on Meehan-Newson soil and in woods than in patches, but differences were not significant.

Discussion

Oak wilt is a localized disturbance which, as it spreads, creates small scattered patches throughout the woodlands that structurally begin to resemble a barrens. We found that oak wilt patches were intermediate to a well-established barrens and surrounding wood-

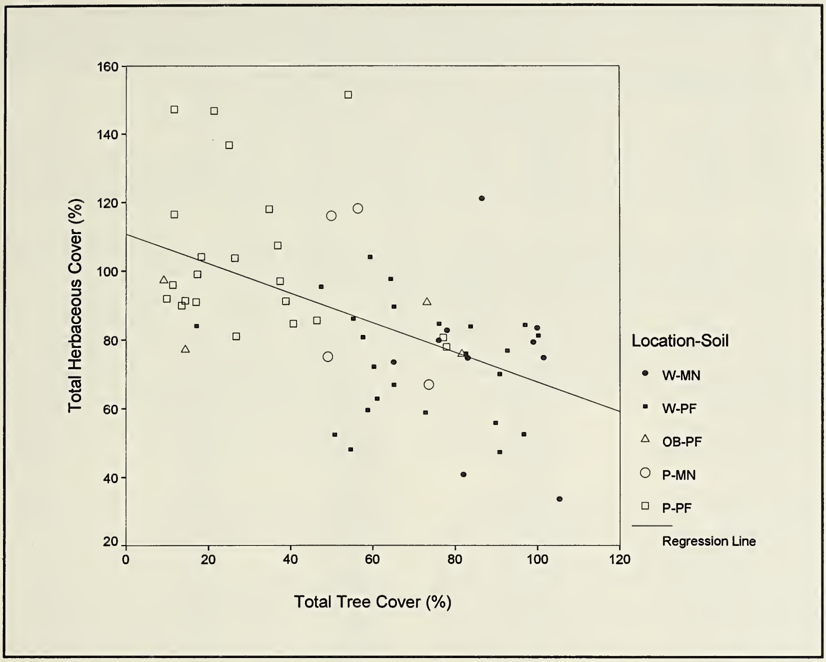

Figure 1. Total ground layer cover as a function of total tree cover for all oak wilt openings and Old Barrens sites. Locations are identified as patches (P), Old Barrens (OB), or woods (W), and soils are identified as Plainfield-Friendship (PF) or Meehan-Newson (MN).

lands in both structure and composition. Herbaceous cover in patches is much higher than in the surrounding woods and, depending on the soil type, was dominated by either forbs or graminoids. However, the ground layer in patches contained more weedy species such as *Galeopsis tetrahit* and *Taraxacum officinale* and far fewer prairie/savanna species than Old Barrens. Total shrub cover was consistently low across all sites. Total tree cover in patches approximated tree cover in Old Barrens and was considerably lower in both than in the woods. The cover of *Pinus banksiana,* which we hypothesized would increase across all strata in oak wilt openings, was significantly higher only in the ground layer on Plainfield-Friendship soil. Total herb cover was negatively correlated to tree cover and was similar in patches and Old Barrens.

Several factors may contribute to the results we observed in this study. Soil type was reported to be a significant factor in the occurrence of oak wilt (Gillespie and True 1959, Bruhn and Heyd 1992), and this was borne out in our study. Oaks in the shallow, droughty, nutrient-poor Plainfield-Friendship soil apparently experience a

Table 3. Average number of species by strata per 10 m segment by soil and location.

Soil	*Site or Location*	*Ground Layer*	*Shrub Layer*	*Tree Layer*
Plainfield-Friendship	Patch	2.57	0.19	0.34
	Old Barrens	4.52	0.24	0.32
	Woods	2.30	0.22	0.50
Meehan-Newson	Patch	4.23	0.46	0.50
	Woods	3.65	0.35	0.76

Table 4. Mean and standard deviation of percent cover for species occurring in Old Barrens and oak wilt patches on Plainfield-Friendship soil.

	Old Barrens		*Patches*	
Species[1]	*Mean*	*S.D.*	*Mean*	*S.D.*
Achillea millefolium	1.1600	1.9667	0.0113	0.0412
Agrostis hyemalis	0.2400	0.1673	0.0000	0.0000
Andropogon gerardii	2.1600	1.2973	0.7037	2.2400
Andropogon scoparius	14.3200	6.0039	0.0515	0.1269
Asclepias tuberosa	0.0600	0.1342	0.0000	0.0000
Aster azureus	0.7600	0.4278	0.0161	0.0609
Baptisia lactea	0.4800	1.0733	0.0000	0.0000
Carex spp.	36.0800	10.3239	65.9729	15.7314
Comptonia peregrina	0.9600	1.8298	0.0000	0.0000
Convolvulus spithamaeus	0.7800	1.3864	0.0000	0.0000
Coreopsis palmata	1.0400	2.2154	0.0000	0.0000
Danthonia spicata	0.5600	0.8173	0.0458	0.2043
Fragaria virginiana	0.1200	0.2683	0.0000	0.0000
Gaylussacia baccata	0.0000	0.0000	4.8140	12.7124
Helianthus occidentalis	3.9200	3.3804	0.0000	0.0000
Houstonia longifolia	0.1600	0.2191	0.0076	0.0260
Koeleria cristata	2.4200	2.5509	0.0327	0.1153
Lechea intermedia	0.1600	0.3050	0.0000	0.0000
Lespedeza capitata	0.0600	0.1342	0.0000	0.0000
Liatris aspera	0.2000	0.2449	0.0000	0.0000
Liatris cylindracea	0.1200	0.2683	0.0000	0.0000
Panicum ssp.	0.3800	0.5848	0.0083	0.0408
Pedicularis lanceolata	0.1400	0.3130	0.0000	0.0000
Physalis virginiana	0.1800	0.2490	0.0000	0.0000
Pinus banksiana	0.4800	0.5450	0.2005	0.5205
Poa pratensis	1.3800	1.5928	0.6374	1.9035
Populus grandidentata (shrub)	2.7600	3.7799	0.0093	0.0454
Populus grandidentata (tree)	1.0230	3.8278	13.8000	23.0634
Rubus spp.	3.4270	7.6789	0.1400	0.3130
Solidago juncea	1.7800	1.5563	0.0035	0.0170
Solidago nemoralis	0.3600	0.4980	0.0000	0.0000
Sorghastrum nutans	0.7800	1.1145	0.0208	0.1021
Spiranthes gracilis	0.0200	0.0447	0.0000	0.0000
Vaccinium angustifolium	2.5000	2.8723	10.8920	8.5607
Viola pedata	0.6000	0.5788	0.0240	0.0690

[1] Only species whose distributions were significantly different are listed.

Table 5. Mean, standard deviation, and significant differences ($P \leq 0.05$) of percent cover for species in oak wilt patches and woods.

	Plainfield-Friendship Soil				*Meehan-Newson Soil*[1]			
	Patches		*Woods*		*Patches*		*Woods*	
Species	*Mean*[2]	*S.D.*	*Mean*[2]	*S.D.*	*Mean*[2]	*S.D.*	*Mean*[2]	*S.D.*
Acer rubrum (ground layer)	0.000^{a}	0.000	0.221^{b}	0.392	0.317^{b}	0.435	0.182^{b}	0.343
Acer rubrum (shrub layer)	0.006^{abc}	0.029	0.000^{a}	0.000	0.800^{b}	1.789	1.729^{b}	5.513
Acer rubrum (tree layer)	0.000a	0.000	1.589^{ab}	4.635	2.000^{b}	4.472	4.987^{b}	9.374
Andropogon gerardii	0.704^{a}	2.240	0.207^{ab}	0.712	0.000^{ab}	0.000	0.000^{b}	0.000
Aronia melanocarpa	0.010^{a}	0.051	0.012^{a}	0.049	0.000^{a}	0.000	1.525^{b}	3.601
Corylus americana (shrub)	0.000^{a}	0.000	0.000^{a}	0.000	0.080^{b}	0.179	0.000^{a}	0.000
Gaylussacia baccata	4.814^{a}	12.712	5.733^{a}	9.909	24.499^{b}	11.199	13.520^{a}	17.947
Pinus banksiana	0.20^{a}	0.520	0.111^{a}	0.152	0.000^{a}	0.000	0.000^{b}	0.000
Pteridium aquilinum	4.012^{a}	7.976	5.089^{ab}	7.006	14.156^{ab}	16.960	13.209^{b}	15.528
Trientalis borealis	0.000^{a}	0.000	0.021^{a}	0.108	0.233^{b}	0.325	0.124^{b}	0.238

[1] No significant difference was reported for any species; superscript applied without regard to possible signifcance or insignificance between species on these sites.

[2] Means with the same superscripted letter were not significantly different.

higher incidence of root grafting, which in turn affects the extent of oak wilt spread and, consequently, patch size.

Most species occurring in Old Barrens are fire adapted and shade intolerant. We hypothesize that the effects of fire, including litter removal, nutrient release, increased pH, warmer soil surface temperatures, increased nutrient availability, and reduction of woody vegetation, will have a different effect than oak wilt alone. We predict, moreover, that fire will have a synergistic effect when combined with oak wilt.

Old Barrens, in addition to originating by fire, is a relatively unfragmented 227 ha area, whereas patches did not exceed 78 m in diameter (0.48 ha). The low richness of savanna species in patches may be influenced by both patch dynamics and fire; recruitment and proliferation of savanna species is more likely to occur in large areas that have existed for decades than in more recently established, small isolated openings scattered throughout a woodland.

This study provides a preliminary framework for understanding the ecological impact of oak wilt on the vegetation of degraded barrens. Oak wilt may restore some savanna species by creating barrens structure in small isolated patches, but other disturbances, notably fire, are probably required to restore a full complement of savanna species. We believe that studies of the interaction of oak wilt and fire will add greatly to our understanding of the successional importance of oak wilt in savannas.

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Linda DePaul and David Kopitzke

Incentives for Savanna Protection on Private lands: Past, Present, and Future

Abstract *In Wisconsin, as in most parts of the eastern one-half of the United States, about 80% of the land is owned by private individuals. These owners may be individuals, families, businesses, and organizations. Their diverse backgrounds, goals, and land ownership sizes create a mosaic of diverse land conditions across the state and present a challenge to landscape-level management. Yet, many of the state's rare species and their associated habitats occur on this land, including prairie brush clover* (Lespedeza leptostachya), *wooly milkweed* (Asclepias lanuginosa), *purple milkweed* (Ascelepias purpurascens), *orchard oriole (Icterus spurius), and loggerhead shrike* (Lanius ludovicianus). *Considering the large percentage of Wisconsin's land base that is privately owned, it is not surprising that many of the known remnants of oak savanna ecosystems occur on privately held acreages.*

Land ownership trends in the Great Lakes region indicate that in the future, private holdings will be more fragmented and will turn over more frequently (Sample et al. 1995). If these important remnants of our once vast oak savanna ecosystems are to remain part of Wisconsin's natural heritage, private land owners must be motivated to play a significant role in their protection. Apart from forestry and agriculture programs, conservation activities traditionally have been largely the province of government agencies or private environmental organizations. Recently, however, the private landowner's contribution has grown in importance and is being recognized. Usually this contribution has depended solely on the goodwill and generosity of a small percentage of concerned landowners.

Encouraging a larger percentage of landowners to commit themselves to savanna restoration, management, and protection requires more compelling incentives than have previously been available. We have listed a variety of currently available incentives offered by private conservation organizations and government agencies, including legislation, technical assistance, payments, and

education. There is much that we can learn from the past and current successes and failures. We will discuss the relative success of each of these methods and will also describe the practical potential types of incentives that could be instituted to encourage private landowners to protect savannas. Continued research, local involvement, and integrated approaches toward savanna management on private lands are all needed to protect this valuable ecosystem.

Birch (1994) states that close to 84% of the land in Wisconsin is privately owned, which is close to the 80% figure that is frequently quoted for all states in the eastern one-half of the United States. Even in western states, rich in public land, usually the majority of the land is privately owned. Nor is this the case only in the United States. In Australia, for example, 70% of the land is in private ownership (Clairs et al. 1997).

It is not surprising, then, that many, if not most, of Wisconsin's rare species and their habitats occur on private lands—owned by individuals, families, businesses, and organizations. This is certainly true of oak savanna plant communities. If this very rare group of plant communities is to remain a healthy part of Wisconsin's biota, then private landowners must play a significant role in its protection.

We adopted a broad definition of a savanna: a grassland with scattered trees. This definition encompasses those communities that John Curtis (1959) called oak openings, scrub oak barrens, pine barrens, and cedar glades. Curtis estimated that at the time of settlement Wisconsin boasted 9,602,500 acres of savanna—more than 25% of the state's total area. Currently, estimates indicate that there are 1,920 acres of savanna, only 0.02% of its former area and, of the total state's acreage, a mere 0.005% The figures show clearly that savannas were once among the most common of plant communities in the state; now they are the rarest.

While some essentially intact oak savanna communities occur on public land, this does not automatically assure their protection or long-term survival. Not all public land managers are trained to recognize savanna structure and species, and oak savanna management techniques are by no means clear. Even the most ardent of oak savanna enthusiasts cannot always be sure if burning is indicated, when to burn, which pesticides are best in all cases, and which species to encourage or discourage. Furthermore, there are not enough public employees who are savanna ecologists to manage all the potential savanna habitat on public land.

This underscores the pressing need for educating the public, especially landowners, on how to identify, protect, and manage (as well as we know how) savannas. In addition, restoration projects are often expensive and labor intensive for the landowner. If we really want to see savanna communities maintained or restored, we should assist the landowner at two levels, education and implementation. What incentives have there been to encourage landowners to take an interest in savannas? To answer this question adequately, we must first look at the history of conservation incentives for private landowners.

History of Government Incentives

Incentives to private forest landowners have appeared in many forms and have a long and rich history. In 1864, George Perkins Marsh published an influential book entitled Man & Nature. Nearly one-half of this book was devoted to the ravages of the forest lands. During 1872 the first set-aside of more than two million acres of spectacular forest lands for preservation from development occurred. This was contrary to the government programs of the day that were targeted at encouraging homesteading. These types of programs essentially gave land away for mining, farming, and rural development.

In 1911 the first public forest policy was passed to encourage specific practices on lands owned by private individuals and businesses. However, since large portions of the American public would not support extensive federal domination on private lands, forest managers and politicians were forced to propose programs limited to "encouraging" better management practices.

Over the last 220 years of our country's history, the acceptance of a larger role for government on private lands has grown. Some of the more important reasons for this acceptance include increasing population numbers, rising incomes and living standards, increased competition for limited resources, broader education, wider suffrage, and growing conservation and environmental concerns. The broad goal of these environmental incentive programs has been to protect the land values that society has determined to be important. Our nation has only 7% of the world's forests but 40% of the world's privately owned forests (Moulton 1994).

The types of incentives that have evolved over time all have both positive and negative aspects associated with them and have limited applicability. There has been no single type of incentive that has proven effective for the majority of landowners and land situations, although attempts have been made consistently to craft just such a program. The most notable type of incentive program that has all too frequently been misapplied is strict regulation by law. These incentives gained much of their momentum out the environmental era of the 1960s, but did not remedy the situations they were created to protect. The basic problem, as George Reiger (1992) states, is that "such legislation . . . was based on the naive premise that only the federal government is big enough and fair-minded enough to deal with problems created with the Corporate State. Unfortunately, just the opposite is true."

Other types of incentives involve purchase of fee simple title, conservation easements, lease and management agreements, registry/awareness programs, and cost-sharing programs. With the large number and types of incentive programs, most with different enabling legislation, intended audiences, rules, and goals, it is not surprising that the programs that were intended to benefit the environment sometimes overlap, confuse, compete, and actually counter each other.

Counterproduction Incentives

With the plethora of incentive programs administered by a variety of agencies, each with a slightly different mission, at times these incentives are diametrically opposed to each other, as in tree planting versus prairie maintenance or animal damage control. The narrow focus or "quick fix" approach of the following incentive programs has led to numerous problems.

1. Tree Planting/Agricultural Planting on Open Sites. Foresters, wildlife biologists, and conservation specialists have historically focused on establishing quick "cover." Tree planting recommendations frequently rely on formulas for spacing and density that establish "full stocking" and straight, clean tree trunks. Such an approach has "fully stocked" as its goal. If tree density falls below 400–500 trees/acre, the planting is not considered successful.

Wildlife and soil conservationists historically have recommended cool season grasses, exotics, and even aggressive exotics because they can be quickly established. There are known techniques to establish them including formulas for planting rates and utilization of fertilizers and lime. Thus, we have treated natural resource management as an agricultural problem to be fixed rather than a complex community to be established, maintained, or restored.

Landowners are the other half of the equation. Because many landowners want instant results and low maintenance, we have more red pine plantations and alfalfa/clover fields than ever before.

Another problem is the paucity of sources of seeds and plants of native species. This results in the high cost of seed/stock when native materials are available. Ecologists encourage landowners to use native species. However, because of the cost, lack of ready availability of plant material, and low demand, it is hard to get nurseries interested in growing natives.

2. Fire Suppression. Public forest management agencies have done such a thorough job of fire prevention and promotion of Smokey the Bear, that every school child knows fire is bad. Unfortunately, we have concentrated on both human and natural-caused fires with little regard to where they occur or what threat they may present. Attempts at instituting "let burn" policies and prescribed burns have generally met with a lack of acceptance by the general public. The infrequent occasions when these fires have escaped have received much negative public attention. The result is that many fire-dependent communities—communities that have historically relied on maintenance of their successional stage through fire—are becoming increasingly rare.

Lightening-caused fires are infrequent in Wisconsin, and most likely, the same was true in the recent past. Because we know of the presence of nomadic hunting tribes throughout the state during most of the postglacial period, we may assume that man-made fires were an important, if not the sole, cause of forest, prairie, and savanna fires (Curtis1959). By eliminating man-caused fires, much of the former prairie and savanna lands are succeeding to brush or forested landscapes.

Some individuals maintain that fire-like conditions can be accomplished without fire. They cite herbicide use, grazing, and mechanical disturbances as safer alternatives. However, no herbicide, animal, or machine can fully mimic the structural and chemical changes a fire produces in the upper soil layer and seed bank.

3. "Perverse" Incentives. One problem that occurs when assistance programs are developed by different government agencies with narrow focuses and constituencies is that the government ends up actually paying landowners to destroy or damage valuable resources. For years environmentalists have pointed out that many government policies encourage or subsidize activities that lead to the loss of species and habitat.

For example, a study by the Environmental Working Group found that U.S. Department of Agriculture (USDA) payments to farmers totaled 108.9 billion dollars in ten years between 1985 and 1994. Despite this, agriculture remains the single largest contributor to water pollution and wetland conversions (Opperman 1997).

For ten thousand or more years, many North American terrestrial ecosystems were periodically burned by indigenous peoples. European settlers often continued this practice, but such fires were halted shortly after the turn of the century, mainly through the efforts of the U.S. Forest Service (USFS). In

1908, Congress passed a law that effectively gave the USFS a blank check for putting out fires. When a fire did take place, the agency could spend whatever it took to suppress the fire with confidence that Congress would reimburse the USFS at the end of the year. It could be argued this law created a perverse incentive that ended up doing far more damage to American forests than clearcutting. No matter how remote the forest, no matter how worthless the timber, fires were quickly suppressed. This radically altered the vegetative composition of the forests (Opperman 1997).

The USDA's Animal and Plant Health Inspection Service (APHIS) animal damage control program conducts active and often lethal campaigns against livestock predators such as coyotes and other animals that may damage agricultural interests. The APHIS program for controlling prairie dogs has resulted in damage to other species as well. There are an estimated 163 vertebrate species dependent on or closely associated with prairie dogs, either as a food source or for the habitat modifications that prairie dog towns provide. These include several endangered species (Opperman 1997).

4. Taxpayer Double Burden. This category includes subsidies that promote habitat conversion or degradation as a "double burden" because taxpayers must pay to subsidize a particular industry or activity and then pay again to recover species and protect them from the subsidized activities. Subsidized programs are those in which income is directly or indirectly transferred from taxpayers, in general, to specific beneficiaries or those in which the beneficiaries of a specific policy do not pay full costs for a project, access to resources, or for a service. We feel that many listed species on federal lands are threatened by subsidized activities.

For example, a series of dams built by the Bureau of Reclamation along the Missouri River inundated 390,000 acres of wetlands and oxbow lakes. These wetlands were homes for several listed species. At the same time 1.2 million acres of wetlands in the Everglades were opened for agriculture or development through the drainage and flood control provided by the Central and South Florida Project. Eighty percent of this project was financed by the Federal government. Both of these subsidized projects destroyed wetlands, homes for many listed species (Clairs et al. 1977). While these wetlands are being destroyed, the U.S. Fish and Wildlife Service spends taxpayer dollars to recover populations of rare species dependant on wetland habitats.

An indirectly subsidized activity that poses degradation threats is recreation. Users of recreation facilities on public lands rarely pay the market value for their activities. These types of activities, including off-road vehicle use, skiing, boating, hiking, or climbing, all have been shown to affect native species. Opperman (1997) states he discovered that 112 listed species found on federal land were affected by recreation, and for 22 species, this was the only or most significant threat.

Current Incentives

Current incentives to initiate conservation practices on private lands fall into two categories. The first depends on the good will of the landowner as it includes voluntary and non-monetary incentives. These include information, encouragement, recognition, and sometimes management assistance. The second category, many examples of which are described later, includes government programs in which management costs are shared between the government and the private landowner.

Voluntary Programs

In 1991 the Wisconsin Department of Natural Resources' Bureau of Endangered Resources initiated its Landowner Contact Project. Begun with a focus on the voluntary protection of two federally listed species, the dwarf lake iris (Iris lacustris) and the dune thistle (Cirsium pitcheri), it has since expended considerably. It now reaches out to assist private landowners on whose properties occur a variety of state and federally listed rare species. It also includes habitat protection for goat prairies and sand prairies.

The Landowner Contact project is simple in conception, but often involves considerable expenditure of time and effort to achieve its goals. Basically, eight steps are followed to achieve protection of rare natural resources on private lands:

1. Determining species and habitats of concern;
2. Doing research using personal contacts and the Natural Heritage Inventory on sites where the resource has been observed;
3. Determining current land ownership at the site;
4. Contacting the landowner via letter, phone call and/or face to face visits offering information and management assistance concerning the rare resource;
5. Visiting the site with the landowner's permission (and often in the company of the landowner) to verify the presence and status of the resource;
6. Negotiating a voluntary protection agreement between the landowner and the Bureau of Endangered Resources;
7. Recognizing the landowner with a certificate and matted illustration;
8. Continuing regular contact with the landowner with offers of further information and help.

So far, the Bureau of Endangered Resource's Landowner Contact project has not focused on savanna protection, though this is being considered.

The Blue Mounds Project uses much the same approach; its goal is to protect native species and their habitats, focusing on private lands in western Dane and eastern Iowa Counties. This eastern edge of the Driftless Area includes prairie, savanna, wetland, and woodland sites occurring amid farms, residences, and commercial woodlots. A key element of the program is the offer of a free four-hour hike over the land during which the landowner learns what plant communities and species currently may be found on the property. Following this may be further contacts during which management and native habitat restoration may be discussed and planned. Savanna remnants do occur in this area, and the possibility of savanna protection and restoration is always a consideration.

During the past few years, The Nature Conservancy (TNC) has focused its attention on a small number of biologically significant large-scale natural areas in the United States. These "Last Great Places" are defined as "the most important areas for biodiversity remaining in the western hemisphere." One of these projects, the Baraboo Hills, occurs in Wisconsin. Though largely forested, the bluffs also contain some prairie and savanna remnants. The Baraboo Bluffs themselves are far too extensive and expensive to be purchased by TNC. Certain "biological gems" are being acquired, but the majority of the bluffs will remain in private ownership; conservation activities on these private lands are being encouraged in several ways. Private landowners are being included in conservation efforts through educational and informational meetings. To augment these meetings, a publication entitled *Baraboo Bluffs Forest Owners' Handbook* (The Nature Conservancy 1995) has been widely distributed. TNC employees working in the Baraboo Bluffs make special note of savanna sites as well as other biologically significant plant and animal communities.

Yet another voluntary conservation option is discussed in *Technology Review* (Anonymous 1996), in which the author discusses outright payments made to private landowners who engage in specific activities. These payments are funded by the conservation organization, Defenders of Wildlife. Resources for such payments are clearly limited, especially in the case of private organizations. Nevertheless, with especially rare resources or resources threatened by unexpected, sudden developments, this is sometimes a suitable solution. An example of this program is the use of Defenders of Wildlife funding to pay for timber wolf damage to livestock as part of the timber wolf reintroduction in Yellowstone National Park.

In all these cases, benefits are multiplied if cooperating landowners have adjacent properties or the properties are clustered in ways that allow for more natural movement of plants and animals across political and ownership boundaries. Exchange of genetic material, adjustment to changing conditions, insect pollination of plants, and recovery from localized disturbances are all enhanced if large numbers of properties located near to each other are the sites of coordinated conservation activities.

Cost-Share Programs and Their Effects on Savannas

The variety of financial assistance programs that have been developed over the years usually focus on agriculture or forestry/forest production. None of the various programs have focused specifically on savannas, and in some instances, such programs have negatively impacted savannas (Haines 1995). A brief run-down of the traditional programs follows:

- Agricultural Conservation Program (ACP): This is sometimes called the "granddaddy" of USDA programs. Since the program started in 1936, it has been instrumental in the planting of more than seven million acres of trees (Moulton 1994). Although this program is no longer available, active contracts still exist. The ACP was developed to provide financial and technical assistance to help institute agricultural conservation and solve environmental problems.

- Forestry Incentive Program (FIP): Established in 1974, the primary objective of the FIP is to increase the nation's timber supply. It focuses specifically on tree planting, tree improvement, and preparation for natural regeneration. By 1994, the FIP had provided cost-share assistance to more than 126,000 private landowners. The emphasis is on "productive" forest land.

- Managed Forest Law (MFL): This is a tax incentive to encourage the management of private forest lands for the production of future forest crops for commercial use. Up to 20% of the land enrolled in the MFL program may be "non-productive," while 80% must be capable of producing a minimum of 20 cubic feet of merchantable timber per acre per year (Tlusty and Roberts 1991).

- Conservation Reserve Program (CRP): This program takes highly erodible and marginal cropland out of production. It provides up to 50% cost-sharing for approved practices during a 10-year (15 years for hardwood trees) contract payment period. Approximately 36 million acres were "retired" from crop production between 1985 and 1995 at an average rental cost of $50 per acre. While it can be expensive, the CRP has demonstrated benefits to endangered species by taking marginal and patchily distributed agricultural land out of production (Jelinski and Kulakow 1996). Farmers are paid to retire highly erodible lands for ten years and obliged to dedicate this acreage to wildlife and watershed protection. The CRP reaped numerous benefits for the flora and fauna of the Great Plains states, including the recovery of many bird populations (Opperman 1997).

- Stewardship Incentive Program (SIP): Established in 1990, SIP was intended to pay part of the cost of a variety of multiple-resource activities. SIP has cost-shared food plots for deer in areas where tree regeneration is already hard to achieve due to deer browsing. SIP can also cost-share tree shelters to protect seedlings. Thus, SIP is another example of a program that sometimes pays for diametrically opposed incentives.
- Environmental Quality Incentives Program (EQIP): This new program targets livestock producers but encourages total resource management.
- Wildlife Habitat Improvement Program (WHIP): This is another new program that has not yet been tested, but does offer some hope for the future. In Wisconsin, threatened and endangered species have been highlighted as a priority concern. Since the WHIP program is so new, there is a chance of adding communities into this category.

Future Management and Incentives

Simply getting landowners to commit themselves to savanna restoration and management is only the first step in a longer process. Indeed, landowners will be hesitant to commit themselves to savanna protection, regardless of the incentives, until they are fully informed about what specific management actions will take place on their acreage. Furthermore, it is necessary to know what management techniques are successful and whether restoration of a degraded site is possible. Currently, the state of our knowledge in this realm is still quite limited.

Some minimal amount of research on management options would provide much needed information for those committed to protecting savannas, whether private landowners or public land managers. Some ecological questions that need good answers include:

1. What are the best methods for clearing overgrown savannas? Do these vary according to invading species, slope, aspect, time of year, and surrounding land use?
2. Can mowing be an acceptable method for maintaining savanna habitats? When should this be done, how frequently, and at what height?
3. How frequently should a savanna in Wisconsin be burned? How does this vary with differences in overstory species, understory species composition, and site history? Can we assume that, like prairie burning, the burning of savannas should sometimes be in spring, sometimes in fall, and that it should be done in a patchy, random fashion to allow for the survival of pollinating insects?
4. Can grazing be a successful method for maintaining savannas? Which species of grazing animals are best for the plant community, in what numbers, and how often may they be released at a savanna site?

Once these questions are answered, planning management activities and creating new effective incentives will become easier.

Conclusions

Professional land managers do not have all the answers, but we are moving in the right direction. We must commit ourselves to doing careful and meaningful research. We must be ready to learn from amateurs and from landowners themselves. Following the model of Integrated Pest Management, perhaps we can devise an Integrated Land Management model that would take into account the needs of savanna plant and animal species along with the needs of landowners for financial and other returns from their property.

We need to continue to debate among ourselves concerning the appropriate balance of forests, savannas, prairies, agricultural land, and land devoted to residences, businesses and industry. Currently we are only hurting ourselves by fighting for limited resources that benefit special interests rather than concerning ourselves with the overall resource base and its needs.

Resource professionals must commit themselves to serving private landowners who own savanna habitat. This includes educating landowners about what a savanna is, why it is important, and how to maintain this rare habitat.

Creative use of existing incentive programs can go far toward savanna protection on private lands. But resource professionals and conservation organizations must also lobby for the enactment by governmental units of newer and more ecologically sound incentive programs. Ideally, a legislative proposal would provide incentives to protect whole native plant and animal communities: savannas, barrens, prairies, wetlands, and forests. The more flexible these programs are, the more likely they are to accommodate protection of diverse habitats and the flora and fauna existing there.

Government programs are only part of the solution to the challenge of protecting savannas. Incentives can be regarded as a stimulus to initiate proper management on private lands. Education and adaptive resource conservation can keep management going. But ultimately, the long-term survival of savanna plant and animal communities will depend on the goodwill, commitment, and intelligence of private landowners working cooperatively with resource professionals.

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Effects of Sericea Lespedeza (Lespedeza cuneata *(Dumont) G. Don)* *Invasion on Oak Savannas in Kansas*

Abstract *Invasion of sericea lespedeza* (Lespedeza cuneata *(Dumont) G. Don) into oak savannas in southeast Kansas altered the composition, structure, and density of the native prairie component of the ecosystem and reduced the number of invertebrate species. Vegetation characteristics in clearings infested with sericea lespedeza were compared with uninfested clearings during the summer of 1996. Eighty 1 m² quadrats were randomly placed in each of the 2 site conditions. The number of grass species decreased from 12 in uninfested sites to 4 in infested sites. Native forb species declined from 27 in the uninfested sites to 8 in the infested sites. Canopy coverage of sericea lespedeza in the infested sites was 84%. Mean stem counts of sericea lespedeza were 352/m². Weight of clipped native grasses and forbs from uninfested sites was 92% greater than in infested sites. Numbers of invertebrate species declined from 65 at the uninfested sites to 24 at the infested sites. Implications of vegetation changes on wildlife populations and forage for livestock are considered.*

Invasions of plants and animals have been occurring in North America since the continents separated. Many of the introductions of exotic species have resulted in the displacement of native species and the disruptions of important ecological processes. Exotic species are one of the greatest threats to native species and to human-disturbed ecosystems in the world (Elton 1958, Fox and Fox 1986, Reid and Miller 1989, Whelan and Dilger 1992, Noss and Cooperrider 1994, Hunter 1996). Rangelands have proven to be especially vulnerable to exotic plant invasions. Exotic grasses and forbs from Europe, Asia, the Mediterranean, and the rest of the world have been a major problem in the native ecological systems of North America

(Baker 1986). Sericea lespedeza (*Lespedeza cuneata* (Dumont) G. Don) is in the initial stages of invasion of Kansas oak savannas and adjacent grasslands and threatens to destroy the quality and productivity of the tallgrass prairie.

Sericea lespedeza, a drought-hardy perennial legume, was first introduced from Japan in 1896 (Magness et al. 1971) and later in the 1930s through the 1950s as a forage crop for healing erosional scars on farmlands, establishing cover on mine spoil banks, and as cover for wildlife (Scott 1995). The long-lived plants are leafy and erect, standing from 0.5 to 1.5 m high. The leaflets are long, narrow and blunt at the terminals. The plant dies back in winter, and new growth arises from crown buds in the spring. It shows low tolerance for shade but thrives in full sun. The current range of this invasive plant has been estimated to be from the Atlantic coast west to Texas and Kansas and north to the Ohio River (Magness et al. 1971).

The invasive impact of this species on Kansas agriculture was recognized in 1988 when the state legislature declared sericea lespedeza a county option noxious weed (Scott 1995). The county-declared option allows the county to penalize land owners who do not control infestations. By 1995, 52 out of 105 counties in Kansas had declared sericea lespedeza a noxious weed. The Pest Risk Analysis (Scott 1995) states that the reported infestation has nearly doubled every 2 years since 1990 in Kansas. This increased reporting is generally agreed to have been generated by the public's increased awareness. Woodson County, where our study area is located, had a reported 21,130 ha infested with sericea lespedeza in 1995. The 1995 Pest Risk Analysis indicates that annual economic impact in the region would approach $29 million assuming a 75% reduction in quality forage available to livestock (Scott 1995).

Many plant species invade apparently because livestock grazing has changed the environment rather than because they are inherently better competitors (Elton 1958, Noss and Cooperrider 1994). Sericea lespedeza is unique in its ability to establish itself in grazed and ungrazed tallgrass prairie and oak savannas.

Our study assessed the changes in the tallgrass vegetation in Kansas oak savannas and associated macroinvertebrates resulting from sericea lespedeza invasion. Vegetative composition, canopy coverage, density of lespedeza stems, yield, and macroinvertebrate numbers in oak savannas clearings infested with sericea lespedeza were compared with uninfested clearings during the summer of 1996. The plant's ability to invade and outcompete the native flora has resulted in a negative effect on the oak savanna ecosystem where it has become established. Reductions in overall species diversity, wildlife habitat and diversity, and quality and quantity of forage were observed in our study.

Study Area

Our study site is located in the Chautaqua Hills, an undulating uplift extending from the Kansas-Oklahoma border to Woodson County, Kansas (Bare 1979). The hills are dissected by deep ravines with occasional sandstone bluffs along the major drainages. Soils are sandy clays and loams with sandstone outcrops of Pennsylvanian age. The tallgrass prairie vegetation is interspersed with groves of blackjack oak (*Quercus velutina* Lam.) and post oak (*Quercus stellata* Wang). Local landowners reported that the infestation of sericea lespedeza on the 295.4 ha study area has occurred within the last 5 to 7 years.

Methods

Grid lines, 150 m in length and set at 25 m intervals on north-south compass lines, were located in the oak savanna clearings in the 295.4 ha study area. Eighty quadrats, each measuring 1 m^2, were randomly placed along the grid lines in clearings infested with sericea lespedeza and 80 quadrats were similarly distributed in clearings that were not infested.

Using McGregor et al. (1986), grass and forb species were identified and recorded in each of the quadrats in the sericea lespedeza infested sites and the uninfested sites during mid-month in June–August 1996. Canopy coverage of forbs and grasses in the infested and uninfested sites were determined by the Daubenmire (1959) method. The density of sericea lespedeza stems in the infested sites was determined by counts of stems in the quadrats. Seedlings less than 6 cm in length were not included.

Yields in g/m^2 of vegetation from the uninfested and infested areas were compared. Vegetation from ten randomly selected 1 m^2 plots from each of the sericea lespedeza infested and uninfested plots was clipped at a height of 6 cm, oven dried for 72 h, and weighed. Samples from the infested plots were pooled and compared to the pooled samples from the uninfested plots.

Macroinvertebrates in the quadrats infested and those not infested were sampled in mid July with 4 sweeps of a 14 inch-diameter insect net through the vegetation of each quadrat in the middle of the day, followed by examination of the quadrats for additional species. Each specimen was identified to family and recorded.

Results

Eight forb species and four species of grasses were identified in the clearings that were infested with sericea lespedeza (Table 1). In the clearings where sericea lespedeza was not present, 24 forb species and 12 species of grasses were identified. Not only did the infested sites have fewer species, but those species identified were of lower forage quality and were generally considered to be weedy.

Canopy coverage measures were found to be in stark contrast in the infested and uninfested areas. While the greatest percent coverage in the uninfested sites was due to grass and forbs other than sericea lespedeza, most of the percent coverage in the infested sites was attributed to sericea lespedeza (Table 2).

Yields of native forbs and grasses differed between the sericea lespedeza infested areas and the uninfested areas. The pooled clippings of native forbs and grasses from the uninfested clearings had a yield of 388.8 g/m^2. The pooled clippings from the infested clearings had a yield of 31.2 g/m^2. The difference between the areas represents a major loss of desirable forage in the infested areas.

Counts of sericea lespedeza stems from infested clearings ranged from densities of 141/m^2 to 466/m^2 ($\bar{x}$ = 352/m^2). Recruitment was considered high. Beneath each bunch of stems, many new sericea lespedeza plants were emerging.

Macroinvertebrate species identified in the infested and uninfested areas also differed. While 65 total species, representing 30 families, were identified from the uninfested areas, only 24 total species, representing 14 families, were identified in the infested areas (Table 3).

Table 1. Native forbs and grasses identified in clearings infested with sericea lespedeza and clearing not infested with sericea lespedeza June – August 1996.

Species in Uninfested Clearings	*Species in Infested Clearings*
Forbs	
Amorpha canescºens Pursh	*Artemisia ludoviciana* Nutt.
Baptisia australis (L.) R. Br.	*Ambrosia psilostachya* DC.
Dalea candida Michx. *ex* Willd.	*Ambrosia trifida* L.
Psoralea tenuiflora Pursh	*Aster ericoides* L.
Schrankia nuttallii (DC.) Standl.	*Solidago missouriensis* Nutt.
Antennaria neglecta Greene	*Vernonia baldwinii* Torr.
Artemisia ludoviciana Nutt.	*Asclepias viridiflora* Raf.
Cacalia atriplicifolia L.	*Linum sulcatum* Ridd.
Circium undulatum (Nutt.) Spreng.	
Echinacea angustifolia D.C.	
Erigeron strigosus Muhl. *ex* Willd.	
Liatris punctata Hook.	
Ratibida columnifera (Nutt.)Woot. & Standl.	
Rudbeckia hirta L.	
Solidago ridiga L.	
Vernonia baldwinii Torr.	
Asclepias viridis Walt.	
Asclepias viridiflora Raf.	
Asclepias syriaca L.	
Allium canadense L.	
Ceanothus americanus L.	
Euphorbia corollata L.	
Ruellia strepens L.	
Salvia azurea Lam.	
Tradescantia bracteata Small.	
Triodanis perfoliata (L.) Nieuw.	
Linum sulcatum Ridd.	
Grasses	
Andropogon gerardii Vitman	*Andropogon gerardii* Vitman
Bouteloua curtipendula (Michx.) Torr.	*Dichanthelium oligosanthes* (Schult.) Gould
Bouteloua gracilis (HBK) Lag. *ex* Griffiths	*Schizachyrium scoparium* Michx.
Bouteloua hirsuta Lag.	*Panicum virgatum* L.
Buchloe dactyloides (Nutt.) Engelm.	
Elymus canadensis L.	
Koeleria pyramidata (Lam.) Beauv.	
Panicum virgatum L.	
Poa pratensis L.	
Schizachyrium scoparium Michx.	
Sorghastrum nutans (L.) Nash	
Sporobolus asper (Michx.) Kunth	

Table 2. Canopy coverage (%) in clearings infested vs not infested with sericea lespedeza, June – August 1996.

	Infested	*Not Infested*
Sericea lespedeza	84	0
Native forbs	10	28
Native grasses	5	79

Discussion

Exotic and native species compete for a variety of resources such as space, water, nutrients, and light. Kalburji and Mosjidis (1993*a*, 1993*b*) have demonstrated that growth inhibitors in sericea lespedeza residues reduce root development in warm- and cool-season grasses. But, there is no data that demonstrate that forbs are also inhibited in this way. An invading species, when it outcompetes the native species present, can alter a variety of ecosystem properties (Hunter 1996). Such is the case with sericea lespedeza in the oak savannas in Kansas. This plant has rapidly invaded the open prairie and oak savanna clearings and altered the composition, density, and vigor of the vegetation. Once established, sericea lespedeza may inhibit or prevent the restoration of native biodiversity. The cost and difficulty of control, as well as other biological issues, combined with limited public understanding, are bound to make control of this invading exotic plant difficult (Westman 1990).

The sericea lespedeza infestation has also reduced the quality and quantity of forage available to livestock. Surviving forbs in most infestation areas are of low nutritive value and are associated with tallgrass prairie in fair to poor condition. Because the plant contains 5–12% tannin, sericea lespedeza has proven to be unpalatable to livestock in most cases. When sericea lespedeza is consumed by cattle, it is only at the earliest time in the season, when the plants are succulent and at their lowest tannin content (Scott 1995).

Table 3. Families and numbers of species of macroinvertebrates in uninfested clearings vs. infested clearings.

	# Species of Macroinvertebrates	
Families	*Uninfested*	*Infested*
Acrididae	5	4
Formicidae	2	2
Cicadellidae	4	
Miridae	6	1
Culicidae	1	
Lygaeidae	2	1
Pentatomidae	2	1
Dolichopodidae	1	
Coccinellidae	3	
Curculionidae	2	
Gryllidae	1	
Noctuidae	2	1
Reduviidae	3	
Salticidae	1	
Tetrigidae	1	
Tettigoniidae	1	2
Nymphalidae	5	1
Chrysididae	1	
Chrysomelidae		3
Muscidae		2
Cydnidae	1	
Mycetophillidae	1	
Scarabaeidae	2	1
Tipulidae	1	
Bombyliidae	3	
Cercopidae	5	3
Dysderidae	1	
Geometridae	1	
Lampyridae	1	
Sphecidae	2	1
Tephritidae	1	
Apidae	3	1
Totals	**65**	**24**

The loss of native plant diversity that occurs when an area becomes infested by sericea lespedeza also results in a loss of invertebrate diversity. Vertebrate diversity is probably affected as well, and further investigation is indicated. Grasses and forbs that are displaced by sericea lespedeza are superior in terms of shelter and food resources, which are of vital importance for wildlife. The native vegetation is home to a rich diversity of invertebrates that may serve as important food sources for prairie wildlife. The high stem density of sericea lespedeza infested areas presents an almost impenetrable barrier to wildlife movement and essentially eliminates the rich diversity of food and cover provided by the native system.

The continued expansion of this exotic species into the tallgrass prairie will profoundly alter the biota and severely damage the region as a source of high quality forage for livestock and as a habitat for wildlife. Although chemical treatments are available, other methods of control must be identified in order to preserve the prairie element of the oak savanna ecosystem.

Acknowledgments

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James O. Evrard

Small Mammals of Northwest Wisconsin Pine Barrens

Abstract *Little is known of the small mammals inhabiting the endangered pine barrens ecosystem in northwest Wisconsin. Early small mammal sampling, which began in 1950, was sporadic and at times haphazard. Systematic sampling of small mammal populations using snap traps throughout the pine barrens was initiated by the Wisconsin Department of Natural Resources in 1993. In 1995, the Great Lakes Indian Fish and Wildlife Commission and the U.S. Forest Service joined the Department of Natural Resources in an expanded coordinated effort to sample four management properties, the Crex Meadows, Namekagon Barrens, Douglas County, and Moquah Barrens Wildlife Areas, located on a southwest/northeast gradient in the northwest pine barrens. Nineteen small mammal species and subspecies were captured using snap traps and pitfall and funnel traps associated with drift fences. Relative small mammal densities, expressed as a catch/effort (C/E) index, varied spatially and temporally and by habitat type and capture technique. Responses to variables were masked by problems associated with field identification of* Peromyscus *spp., intrinsic small mammal population fluctuations, and competition/exclusion among small mammal species.*

In the early 1990s, the focus of research conducted by the Wisconsin Department of Natural Resources (WDNR) began shifting from single species to communities to ecosystems (Gomoll et al. 1995). This focus included increased interest in rare and threatened ecosystems such as the pine barrens. Forest succession due to effective wildfire control and primarily red pine *(Pinus resinosa)* plantations have reduced early successional stages of the pine barrens to only about 1% of the original area in Wisconsin (Riegler 1995). Increased interest in this endangered ecosystem was manifested in the sponsorship of a pine barrens workshop by the WDNR in 1993

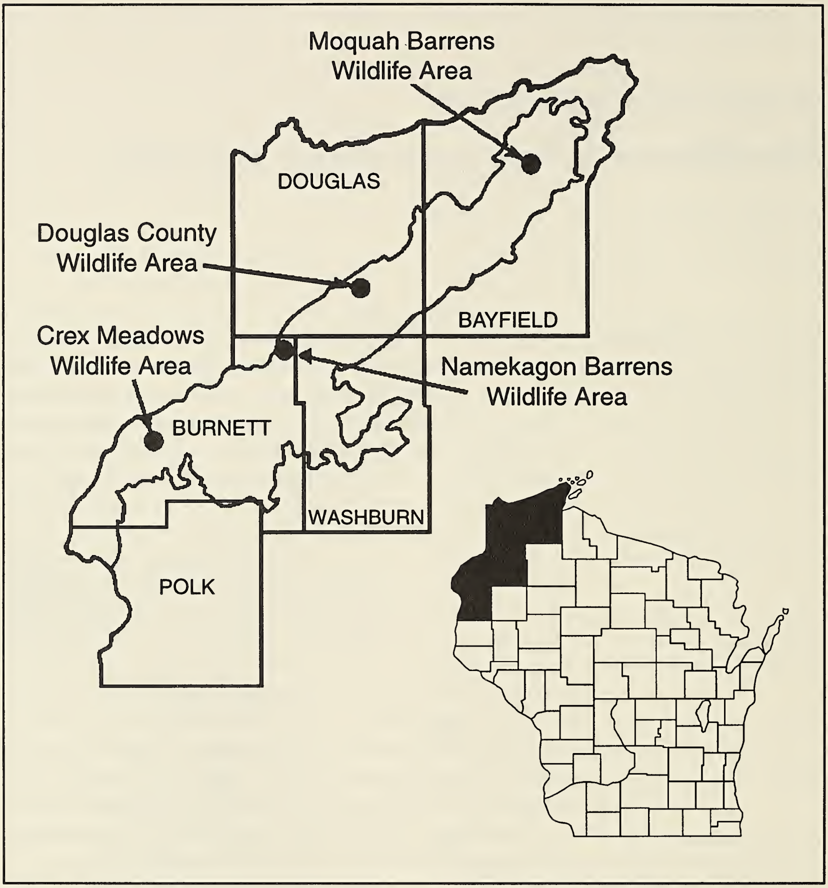

Figure 1. Northwest Wisconsin Pine Barrens showing four properties studied.

(Borgerding et al. 1995). Developing a management plan for the northwest pine barrens was a major workshop recommendation.

Not much is known of the small mammals inhabiting the pine barrens in northwest Wisconsin (Figure 1). During 1950–57, the Wisconsin Conservation Department conducted small mammal surveys throughout the state using snap traps (Bole 1939, Dice 1941, Stickel 1946, Hayne 1949). Two trap lines were in the Crex Meadows Wildlife Area (CMWA) in western Burnett County (N. Stone, Wisconsin Conservation Department, unpublished data). A decade later, Beck and Vogl (1972) reported results from snap-trapping small mammals in the CMWA in August 1967. In 1983, a student intern from the University of Wisconsin-

Stevens Point conducted a survey of small mammals in the CMWA (Brockman 1983). She used snap traps and pitfall traps designed to capture reptiles and amphibians.

In 1978, another student from the University of Wisconsin-Stevens Point used snap traps and pitfall traps to capture small mammals in a variety of habitats on the Namekagon Barrens Wildlife Area (NBWA) in extreme northeast Burnett County (D. Jansen, University of Wisconsin-Stevens Point, unpublished data). In 1986, additional small mammal trapping in the NBWA was conducted by the WDNR using snap and live traps (G. Dunsmoore and J. Riemer, Wisconsin Department of Natural Resources, unpublished data). The methodology and results of the past small mammal trapping was poorly documented and varied considerably.

Part of a WDNR research project I initiated in 1993 involved comparing the effects of clear-cutting and prescribed burning upon pine barrens flora and fauna. In this study, I focused on documenting small mammal populations inhabiting pine barrens, their habitat preferences, and their responses to two major forces that shape the present pine barrens ecosystem: logging and fire.

Study Area

The northwest Wisconsin pine barrens have been described in detail by Curtis (1959), Vogl (1970), Mossman et al. (1991), and Niemuth (1995). Murphy (1931) described the area as ". . . a long narrow strip of sand where coniferous forest and open expanses of sweet fern and grassy barrens dwarf into insignificance the few evidences of man's present occupancy and use of the land. . . . The grassy and sweet fern barrens. . . . are desolate open tracts where only an occasional charred stump, a cluster of jack pines, or a scrub oak bush, breaks the monotonous sweep of rolling, thinly clad ground surface . . . . Almost every year forest fires sweep sections of the Barrens. . . ."

Today, the effects of man on this landscape are more evident. Much of the pine barrens are managed for wood products in private, county, state, federal, and industrial forests. What remains in early successional stages of the pine barrens is found primarily in four areas managed with controlled fire for sharp-tailed grouse *(Tympanuchus phasianellus)* (Figure 1). The CMWA is owned and managed by the WDNR. The NBWA is managed by the WDNR on lands leased from Burnett County as is the Douglas County Wildlife Area (DCWA), which is mostly leased from Douglas County. The Moquah Barrens Wildlife Area (MBWA) is owned and managed by the U.S. Forest Service. Infrequent wild fires and large clear-cuts resulting from salvage logging due to jack pine budworm *(Choristoneura pinus)* outbreaks temporarily create additional early successional habitat on publicly and privately owned forest lands.

Methods

In a cooperation with the University of Wyoming (Niemuth 1995), the WDNR snap-trapped small mammals in seven study plots in June 1993 and in five study plots in July 1994. These plots were located in burned and clearcut areas in county and industrial forests in Burnett and Douglas counties. Each 0.2-ha plot or grid consisted of 50 snap traps (40 mouse- and 10 rat-size) in 5 rows of 10 traps each. Both the rows and the traps were located 7.6 m apart. The traps were baited with peanut butter and checked daily for 5 days, resulting in a total of 1,750 trap nights in 1993 and 1,250 trap nights in 1994. Results were expressed as an index to the population, the adjusted catch/effort (AC/E) index, (Nelson and Clark 1973), which is corrected for sprung traps. Mammals were identified to species in the field. Due to difficulties in field identification of *Peromyscus* spp. (Hooper 1968, Stromberg 1979, McGowan 1980, Long and Long 1993), deer mice and white-footed mice were generally recorded as one species. These were the same trapping methods I used in earlier research conducted managed grasslands in St. Croix and Polk counties in west-central Wisconsin (Evrard 1993).

Beginning in 1995, I initiated more intensive small mammal trapping in the study area, using the same timing and methodology as in 1993–94. As part of research to determine the impact of prescribed burning and clear-cutting in the NBWA, nine grids were trapped in three areas of jack pine *(Pinus banksiana)*/Hill's oak *(Quercus ellipsoidalis)* forest. Three grids were trapped in an intermediate-aged, uncut forest, and another three grids were trapped in a forest that was clearcut in 1990–91 and 1994–95. The final three grids were trapped in a clearcut forest that was burned in late April 1996.

In 1995–97, I also trapped three grids (forest, old burn, and new burn) in the CMWA. The three areas sampled included a mature Hill's oak forest having a thin shrub understory; an area of brush prairie (Strong 1880) that was burned in the spring one year prior to trapping; and an area of brush prairie that was burned 6–8 weeks prior to trapping. The brush prairie was located within a designated state natural area.

In a 1995 cooperative effort, three grids were trapped in the DCWA (G. Kessler, WDNR, unpublished data) and four grids in the MBWA (P. David, Great Lakes Indian Fish and Wildlife Commission, unpublished data). In 1996, the cooperative effort was repeated with the exception of the DCWA. Both properties were cooperatively trapped in 1997.

The three areas sampled in the DCWA included an open grassland burned in 1993 and dominated by sweetfern *(Comptonia peregrina)*; an area containing only hoary puccoon *(Lithospermum canescens)* and a few young aspen (*Populus* spp.) and willow (*Salix* spp.) that survived a fire in the fall of 1996; and an area of tall grass containing shrubby willow and young aspen burned in 1990.

The four areas sampled in the MBWA included an area of young oak trees (oak forest) with little understory had been lightly burned in 1993; an area clearcut (old clearcut) several years prior to 1995 and had thick, brushy ground cover; a third area (old burn) was burned in 1991 and had a well-developed, brushy understory including many berry-bearing species; and the fourth area (new burn) was burned in the spring of 1995 and had a thin ground cover.

Selected captured small mammals were frozen for species identification confirmation by Charles A. Long, Curator of the University of Wisconsin-Stevens Point Zoological Museum and Richard Bautz, WDNR Research, Monona.

In addition to snap-trapping, drift fences (Vogt and Hine 1982) were also operated in the CMWA, NBWA, DCWA, and MBWA in 1996–97 to sample reptiles and amphibians. Small mammals were captured in pitfall and funnel traps (Imler 1945) associated with the drift fences. Drift fences, 15.2 m in length, were constructed of 46 cm high aluminum roof flashing in either a "T" of "I" design adjacent to a wetland. Each drift fence contained from 8–10 pitfall traps and 2–5 wire-mesh funnel traps. The pitfall and funnel traps were opened for four 6-day periods from late April to early June following significant precipitation events. The small mammals drowned in water maintained in the pitfall traps to prevent desiccation of amphibians. Trapping results were expressed as a C/E index since there was no adjustment for "snapped" or unavailable traps.

Thus, small mammals were sampled using two different trapping methods in several habitat types from four core management properties located along a southwest/northeast gradient in the northwest pine barrens (Figurel).

I compared the 1993–97 pine barrens snap-trapping results with 1989–90 snap-trapping results in seven plots located in managed upland grassland in St. Croix and Polk counties (Evrard 1993). Trapping in terms of timing and effort were equal in both studies, although there were differences in habitat sampled.

I used paired *t*-tests and 2-way and 3-way ANOVA (SAS 1989) to compare AC/E and C/E differences for small mammal species relative abundance between trapping methods, habitat types, and management properties.

Results and Discussion

Species Distribution

Nineteen small mammal species were captured using snap traps and pitfall traps in the CMWA, NBWA, DCWA, and MBWA during the period 1995–97 (Table 1). The masked shrew *(Sorex cinereus)*, pigmy shrew *(Microsorex hoyi)*, thirteen-lined ground squirrel *(Spermophilus tridecemlineatus)*, red-backed vole *(Clethrionomys gapperi)*, meadow vole *(Microtus pennsylvanicus)*, and the meadow jumping mouse *(Zapus hudsonius)* were trapped in all four properties. In addition, the woodland deer mouse *(Peromyscus maniculatus gracillis)* and the white-footed mouse were trapped on all four properties. The identification of *Peromyscus* spp., including the prairie deer mouse *(Peromyscus maniculatus bairdii)* was verified from

Table 1. Small mammals captured in Wisconsin's northwest pine barrens, 1995–97.

	Crex Meadows	*Namekagon Barrens*	*Douglas County*	*Moquah Barrens*
Masked shrew	X	X	X	X
Arctic shrew				X
Pigmy shrew	X	X	X	X
Shorttail shrew	X	X	X	
Star-nosed mole				X
Longtail weasel		X		
Shorttail weasel	X			
Thirteen-lined ground squirrel	X	X	X	X
Eastern chipmunk		X	X	X
Least chipmunk		X	X	
Red squirrel		X		
Woodland deer mouse	X	X	X	X
Prairie deer mouse		X	X	
White-footed mouse	X	X	X	X
Southern bog lemming			X	
Red-backed vole	X	X	X	X
Meadow vole	X	X	X	X
Meadow jumping mouse	X	X	X	X
Woodland jumping mouse			X	

voucher specimens identified by Charles A. Long.

Some species were captured on only one property. This included the arctic shrew *(Sorex arcticus)* in the NBWA, the southern bog lemming *(Synaptomys cooperi)* and the woodland jumping mouse *(Napaeozapus insignis)* in the DCWA, and the star-nosed mole *(Condylura cristata)* in the MBWA.

Due to the trapping methods used, the red squirrel *(Tamiasciurus hudsonicus)*, shorttail weasel *(Mustela erminea)*, and the longtail weasel *(M. frenata)* were considered accidental captures.

Three additional species, the northern water shrew *(Sorex palustris)*, the Franklin's ground squirrel *(Spermophilus franklinii)*, and the pine vole *(Pitymys pinetorum)*, were recorded in the northwest pine barrens by earlier workers. The northern water shrew was reportedly trapped in the NBWA (D. Jansen, University of Wisconsin-Stevens Point, unpublished data). Brockman (1983) reported capturing the Franklin ground squirrel and pine vole in the CMWA.

Population Indices

Seven species were snap-trapped in the pine barren grids of Burnett and Douglas counties in 1993–94 compared to four species in 1989–90 in the grassland grids in St. Croix and Polk counties (Table 2).

The thirteen-lined ground squirrel and red-backed vole were the most common small mammals trapped in the pine barrens grids while *Microtus* spp. (mostly meadow voles with a few prairie voles, *M. ochrogaster)*, thirteen-lined ground squirrel, and *Peromyscus* spp. were the common species in the more southern grasslands (Table 2). Despite relative densities of small mammals, expressed as AC/E, apparently being 4–6 times higher in the managed grassland grids examined in St. Croix and Polk counties

Table 2. Adjusted Catch/Effort[a] for small mammals captured in snap traps in Burnett and Douglas counties, 1993–94 and St. Croix and Polk counties, 1989–90.

	Burnett/Douglas		*St. Croix/Polk*	
Species	*1993*[b]	*1994*[c]	*1989*[b]	*1990*[b]
Masked shrew	0.00	0.00	0.06	0.06
Shorttail shrew	0.07	0.00	0.00	0.00
Thirteen-lined ground squirrel	0.29	0.66	0.74	1.40
Eastern chipmunk	0.07	0.00	0.00	0.00
Least chipmunk	0.14	0.00	0.00	0.00
Deer and white-footed mice	0.07	0.17	0.80	0.76
Red-backed vole	0.07	0.42	0.00	0.00
Meadow and prairie voles	0.00	0.17	3.21	3.82
Meadow jumping mouse	0.07	0.08	0.00	0.00
Total	0.78	1.50	4.81	6.04
$\bar{x}$	0.09	0.17	0.53	0.67
SD	0.09	0.23	1.06	1.28

[a]Adjusted Catch/Effort = $\dfrac{\text{A (number animals trapped) x 100}}{\text{TU (trapping interval x length of interval x number of traps) – IS (total number of traps snapped)/2}}$ (Nelson and Clark 1973).

[b]1,750 trap nights (7 grids x 50 traps x 5 nights).
[c]1,250 trap nights (5 grids x 50 traps x 5 nights).

than in the early successional grids of the pine barrens, the differences were not significant (F = 1.528, P = 0.25).

Small mammal numbers varied by species between the pine barrens properties trapped during 1995-97 (F = 3.201, P = 0.005). In 1995, the AC/E for all species from snap-trapping in the DCWA was only half of that for the CMWA, NBWA, and MBWA (Table 3). In 1996, the small mammal index AC/E for the CMWA, NBWA, and MBWA grids declined from the previous year. No trapping was conducted in the DCWA in that year. *Microtus* spp. and *Peromyscus* spp. decreased while thirteen-lined ground squirrels increased. In 1997, the AC/E for all small mammals snap-trapped on the CMWA showed little change from 1996 and increased for the NBWA and MBWA. The 1997 index for the DCWA could be compared only to that from 1995 which was higher.

While intended to capture amphibians and reptiles, the C/E for some small mammal species captured in pitfall traps associated with drift fences was comparable with the AC/E for snap traps. In 1996, the drift fence capture indices showed considerable variation among the four properties (Table 4). From 1996 to 1997, the C/E for all small mammals increased on all four barrens properties. However, some species increased on one property and decreased on another property in the same year. In both years, the C/E index was larger on the NBWA than the other three properties. In 1996, the leading species captured in the NBWA was the red-backed vole and the meadow jumping mouse. In 1997, red-backed voles decreased and jumping mice increased.

Meadow jumping mice were captured in only one year in one pine barrens property using snap traps. In contrast, jumping mice were captured in pitfall traps in all four properties in both years of trapping. Pitfall traps associated with drift fences captured more masked shrews (t = 2.332, P = 0.06) than snap traps, while snap traps captured significantly (t = 2.871, P = 0.03) more thirteen-lined ground squirrels than pitfall traps. Differential vulnerability of some small mammal species to different types of traps has been reviewed by McGowan (1980) and reported by Pendleton and Davison (1982).

Since jumping mice prefer wet, grassy habitat (Jackson 1961), the location of drift fences adjacent to wetlands may have been responsible for the large number of jumping mice captured. The shrews may have been attracted to the large numbers of insects trapped in the pitfall traps.

The C/E index derived from drift fence captures probably underestimated changes in relative small mammal population sizes. This is due to the long trapping periods involved (24–56 days) compared to the 5-day trapping period used for capturing small mammals with snap traps. Previous research (Bole 1939, Pelikan and Zejda 1962) has shown that most of the resident small mammal population in the trapped area are captured during the first 3–5 days of trapping.

Habitat Preferences

When snap-trapped small mammals were examined based upon habitat types (burned, clearcut, and forested) across the four barrens properties, differences existed among all small mammal species (F = 17.64, P = 0.0001), years (F = 3.95, P = 0.03) and species/habitat interaction (F = 3.83, P = 0.0003). When only the four most common species, *Peromyscus* spp., thirteen-lined ground squirrel, meadow vole, and red-backed vole, were examined, the same differences of species (F = 9.53, P = 0.002), years (F = 4.57, P = 0.03), and species/habitat interaction (F = 5.36, P = 0.007) existed.

Table 3. Adjusted Catch/Effort[a] for small mammals captured in snap traps in Wisconsin's northwest pine barrens, 1995–97.

	Crex Meadows[b]			Namekagon Barrens[c]			Douglas County[b]			Moquah Barrens[d]		
	1995	*1996*	*1997*	*1995*	*1996*	*1997*	*1995*	*1996*	*1997*	*1995*	*1996*	*1997*
Short-tailed shrew	0.00	0.00	0.00	0.05	0.00	0.00	0.00	—	0.14	0.00	0.00	0.00
Masked shrew	0.00	0.00	0.00	0.00	0.00	0.00	0.28	—	0.00	0.00	0.00	0.11
Arctic shrew	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.11
Thirteen-lined ground squirrel	0.14	0.57	0.00	0.09	0.14	0.33	0.30	—	0.41	0.21	0.44	0.76
Eastern chipmunk	0.00	0.00	0.00	0.05	0.00	0.05	0.15	—	0.00	0.00	0.11	0.00
Least chipmunk	0.00	0.00	0.00	0.62	0.23	0.15	0.00	—	0.00	0.00	0.00	0.00
Red squirrel	0.00	0.00	0.00	0.00	0.05	0.00	0.00	—	0.00	0.00	0.00	0.00
Deer mouse	1.16	0.57	0.14	0.19	0.19	0.79[a]	0.91	—	0.00	1.27	0.22	0.22
White-footed mouse	1.30	0.57	0.00	0.47	0.33	—	—	—	—	—	—	—
Red-backed vole	0.58	0.00	1.70	1.47	0.94	0.98	0.15	—	0.00	0.42	0.00	0.00
Meadow vole	0.00	0.00	0.00	0.19	0.00	0.14	0.00	—	0.00	1.27	0.00	1.95
Meadow jumping mouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.21	0.00	0.00
Total	3.18	1.71	1.84	3.08	1.88	2.44	1.79	—	0.55	3.38	0.77	3.15
$\bar{x}$	0.29	0.16	0.17	0.28	0.17	0.22	0.16	—	0.05	0.31	0.07	0.29
SD	0.74	0.37	0.51	0.46	0.30	0.35	0.27	—	0.13	0.50	0.14	0.60

[a] Adjusted Catch/Effort (Nelson and Clark 1973.
[b] 750 trap nights (3 grids x 50 traps x 5 nights).
[c] 2,250 trap nights (9 grids x 50 traps x 5 nights.
[d] 1,000 trap nights (4 grids x 50 traps x 5 nights).

Table 4. Catch/Effort[a] for small mammals captured in pitfall and funnel traps in Wisconsin's northwest pine barrens, 1996–97.

	Crex Meadows[b]		*Namekagon Barrens*[c]		*Douglas County*[d]		*Moquah Barrens*[e]	
	1996	*1997*	*1996*	*1997*	*1996*	*1997*	*1996*	*1997*
Masked shrew	0.15	0.58	0.87	0.17	0.45	0.91	0.00	0.00
Pigmy shrew	0.05	0.10	0.00	0.75	0.00	0.15	0.51	1.67
Shorttail shrew	0.10	0.10	0.00	0.17	0.00	0.15	0.00	0.00
Star-nosed mole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Longtail weasel	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
Shorttail weasel	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Thirteen-lined ground squirrel	0.00	0.00	0.09	0.08	0.15	0.30	0.00	0.00
Least chipmunk	0.00	0.00	0.00	0.08	0.15	0.00	0.00	0.00
Deer/white-footed mice	0.00	0.00	0.35	0.42	0.45	0.00	0.38	0.13
Red-backed vole	0.05	0.05	2.34	1.25	0.00	0.00	0.00	0.00
Meadow vole	0.00	0.20	0.52	0.33	0.00	0.91	0.00	0.64
Southern bog lemming	0.00	0.00	0.00	0.00	1.06	0.45	0.00	0.00
Meadow jumping mouse	0.15	0.58	2.52	5.33	0.45	0.00	0.13	0.00
Woodland jumping mouse	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
Total	0.50	1.66	6.69	8.66	2.71	3.02	1.02	2.57
$\bar{x}$	0.04	0.12	0.48	0.62	0.19	0.22	0.07	0.18
SD	0.06	0.20	0.87	1.40	0.31	0.32	0.16	0.46

[a]Catch/Effort = $\frac{A \times 100}{TU}$ (Nelson and Clark 1973)

[b]2,056 trap nights (2 drift fences x 20 traps x 56 nights). Data courtesy of Steve Hoffman, WDNR, Grantsburg.
[c]1,152 trap nights (3 drift fences x 16 traps x 24 nights).
[d]660 trap nights (2 drift fences x 10 traps x 33 nights). Data courtesy of Greg Kessler, WDNR, Brule.
[e]780 trap nights (3 drift fences x 10 traps x 26 nights). Data courtesy of Peter David, Great Lakes Indian Fish and Wildlife Commission, Odanah, Wisconsin.

In 1995, the AC/E for all small mammals captured with snap traps in recently burned areas in the CMWA, DCWA, and MBWA was less than that for clearcut and forested areas in the same areas (Table 5).

The following year, the AC/E for all small mammals decreased somewhat for recently burned areas in the CMWA, DCWA, and MBWA but declined precipitously for the clearcut and forested areas. This decline was due primarily to declines in *Peromyscus* spp. and red-backed voles.

In 1997, the AC/E for numbers of all small mammals continued their decline in the burned areas of all four wildlife areas, but increased in the clearcut and forested areas (Table 5). This increase was primarily due to increased numbers of *Peromyscus* spp., most likely white-footed mice, and red-backed voles. Meadow voles and thirteen-lined ground squirrels also increased in the clearcut areas.

There were several problems that complicated the analysis of information obtained in this study, including the cyclic behavior of voles (*Microtus* spp.) (Krebs and Myers 1974, Birney et al. 1976, Hansson and Henttonen 1988, many others) and fluctuations of white-footed mouse *(Peromyscus leucopus)* populations (Popp et al. 1989). This intrinsic variation in numbers from year to year and from location to location could mask population responses by these species to different habitat types or habitat changes.

Table 5. Adjusted Catch/Effort[a] for small mammals captured in snap traps by habitat type in Wisconsin's northwest pine barrens, 1995–97.

	Burned			*Clearcut*			*Forested*		
Species	*1995*[b]	*1996*[c]	*1997*[d]	*1995*	*1996*	*1997*	*1995*	*1996*	*1997*
Masked shrew	0.12	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Arctic shrew	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00
Thirteen-lined ground squirrel	0.31	0.67	0.61	0.06	0.00	0.42	0.09	0.00	0.00
Red squirrel	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Eastern chipmunk	0.06	0.00	0.05	0.06	0.00	0.11	0.00	0.00	0.00
Least chipmunk	0.00	0.18	0.09	0.80	0.21	0.00	0.00	0.00	0.00
Deer/white-footed mice	1.06	0.60	0.23	0.73	0.11	0.85	2.23	0.88	1.48
Red-backed vole	0.12	0.49	0.19	1.35	0.64	0.85	1.38	0.50	1.48
Meadow vole	0.67	0.00	0.37	0.30	0.00	1.27	0.00	0.00	0.07
Meadow jumping mouse	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	2.40	2.03	1.63	3.30	1.06	3.61	3.70	1.38	3.03
$\bar{x}$	0.24	0.20	0.16	0.38	0.11	0.36	0.37	0.14	0.30
SD	0.35	0.27	0.20	0.47	0.20	0.47	0.78	0.30	0.62

[a]Adjusted Catch/Effort (Nelson and Clark 1973).
[b]Seven burned grids (1,750 trap nights), 7 clearcut grids (1,750 trap nights), and 5 forested grids (1,250 trap nights).
[c]Seven burned grids (1,750 trap nights), 4 clearcut grids (1,000 trap nights), and 5 forested grids (1,250 trap nights)
[d]Nine burned grids (2,250 trap nights, 4 clearcut grids (1,000 trap nights), and 6 forested grids (1,500 trap nights).

There is also a tendency for some small mammal species to compete and displace other species (Kirkland and Griffin 1974, Crowell and Pimm 1976, reviewed by McGowan 1980, Vickery 1981, Adler et al. 1984, Swihart and Slade 1990, Nichols and Conley 1981), also influencing habitat use.

Burning reduces forbs and woody plants and debris, habitat that white-footed mice (M'Closkey and Lajoie 1975, Kitchings and Levy 1981, Kaufman et al. 1983, Clark et al. 1987, McMurry et al. 1996) and red-backed voles prefer (Gunderson 1959, Beck and Vogl 1972, Yahner 1983). Burning also reduces the litter layer that *Microtus* spp. prefer (Moreth and Schramm 1972, Kantak 1981, Snyder and Best 1988). Resprouting of fire-killed woody plants and the accumulation of litter in years following fire apparently improves the habitat for white-footed mice and red-backed and meadow voles.

However, deer mice numbers increase in the year of the burn (Beck and Vogl 1972), then decline to pre-burn levels in years following the burn (reviewed by McGowan 1980, Peterson et al. 1985, Snyder and Best 1988, Garman et al. 1993), a response opposite to that of white-footed mice. Since the two *Peromyscus* species were lumped together as one species in this study, their different responses to fire could not be demonstrated. Thirteen-lined ground squirrels were most numerous in burned areas which agrees with earlier findings of Vogl and Beck (1972) for the northwest Wisconsin pine barrens.

Conclusions

The species composition of the small mammal community sampled within the northwest Wisconsin pine barrens varied by location, habitat type, year, and capture technique. Burning initially reduced the numbers of meadow voles, *Peromyscus* spp., and red-backed voles, but increased the number of thirteen-lined ground squirrels. Small mammal indices in the clearcut and forested areas were overall greater than in the burned areas during the period sampled.

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Andrew Hipp

A Checklist of Carices for Prairies, Savannas, and Oak Woodlands of Southern Wisconsin

Abstract *Sedges (genus* Carex*) rivaled grasses in diversity and abundance in presettlement prairies and oak woodlands of the midwest, yet there has been relatively little published of the ecology, even the habitat preferences, of southern Wisconsin* Carex *species. Few data are available from presettlement accounts, and modern studies of prairie and oak savanna flora are too often incomplete or inaccurate with regard to sedges, or have limited application to the southern Wisconsin flora. In order to assemble a summary of prairie and oak woodland sedge habitats, I inspected vouchers deposited at the University of Wisconsin-Madison Herbarium for each of the 133 Wisconsin carices occurring south of the tension zone. From this study I identify seventy-four* Carex *species that occur in today's prairies and oak woodlands in Wisconsin. I summarize statewide habitat distributions for each of these from information recorded on labels of herbarium specimens and provide information on associates where such data are available for prairies and oak woodlands. I further identify forty-four carices as relatively certain members of the presettlement prairie and oak woodland flora and recommend them for planting in restorations. This document is especially intended for use by restorationists, whose work may prove indispensable in refining our understanding of midwest* Carex *ecology.*

Wisconsin is home to over a hundred and fifty species of *Carex,* which inhabit a nearly full range of light, moisture, and soil conditions. As is the case in temperate regions worldwide, *Carex* is unquestionably among the state's most "widespread and ecologically important genera of vascular plants" (Reznicek 1990). Yet a lack of publication and field education has contributed to a regrettable paucity of common knowledge about the ecology of this beautiful and pervasive genus.

Carex very likely makes up four to seven percent of the groundlayer diversity in midwest oak savannas (Delong and Hooper 1996, McCarty in press). Workers in adjacent states (Voss 1974, Wheeler and Ownbey 1984, Swink and Wilhelm 1994, Wilhelm 1995) have compiled habitat information on the sedges of their area by reference to herbarium specimens and field research. Others have included sedge species in more comprehensive hypothetical oak savanna or prairie floras derived primarily from bibliographic records (Gould 1941, Bray 1960, Packard 1988*b*, Bowles and McBride 1994, Delong and Hooper 1996, Ladd 1997) or by a combination of bibliography and fieldwork (Curtis 1959, Hujik 1995, Leach 1996, Bader and Fifield-Murray in review). But many of the reports from adjacent states do not completely accord with field observations in Wisconsin, because relatively minor shifts in geology and climate may significantly alter the habitat requirements of the plants studied (see Discussion section below). Moreover, field and bibliographic studies often treat only those sedges with which the workers are already familiar and occasionally report seemingly inaccurate habitat accounts without a satisfying explanation of methods. Regrettably, *The Vegetation of Wisconsin* (Curtis 1959) gives very incomplete information about the role of *Carex* in the communities delimited and studied, and the reports of Wisconsin's presettlement *Carex* flora are practically nonexistent, suggestive though the few direct accounts may be (e.g., Cheney and True 1893).

I have sought to identify *Carex* species of Wisconsin's prairies, oak woodlands, and oak savannas by reference to habitat information recorded on the labels of specimens housed at the University of Wisconsin-Madison Herbarium (WIS). While one cannot directly determine what species were present in Wisconsin's presettlement savannas due to the almost utter loss of habitat (Curtis 1959, Nuzzo 1986, Leach and Ross 1995, Leach 1996), a summary of the known habitats of Wisconsin's carices may illuminate the roles that those species played in the presettlement landscape.

Methods

Unless otherwise indicated, habitats presented in the Results section of this paper are summarized solely from information available on labels of *Carex* specimens housed at WIS. These specimens have been collected from throughout the state, mapped, and inspected by multiple experts. Due to the diligent caricographic work of Theodore S. Cochrane and the late Dr. James H. Zimmerman, which began in the late 1940s, the collection at WIS represents a relatively complete and accurate portrayal of the state's *Carex* flora. I also searched the herbarium of the Milwaukee Public Museum for vouchers of rare species; none of the species of interest were represented in the collection.

I inspected all species known to occur south of and within the tension zone as identified by Curtis (1959) (Table 1), a total of 133 species comprising around 8,000 vouchers; Cochrane's meticulous township maps of WIS collections were

Table 1. Species inspected. These are the specific epithets of carices that were considered for inclusion in this paper. Two of them ('+') are not known to be members of Wisconsin's flora—but were inspected because of their inclusion in the Wisconsin section of Ladd's (1997) tallgrass prairie species list. Six ('*') are introduced or adventive species that probably were not present in Wisconsin before European settlement.

albicans var. *albicans*	*emoryi*	*paupercula*
albicans var. *emmonsii*	*festucacea*	*peckii*
albursina	*flava*	*pedunculata*
alopecoidea	*foenea*	*pellita*
aquatilis	*folliculata*	*pensylvanica*
arcta	*formosa*	*plantaginea*
assiniboinensis	*gracilescens*	**praegracilis*
atherodes	*gracillima*	*prairea*
aurea	*granularis*	*prasina*
backii	**gravida*	*projecta*
bebbii	*grayi*	*pseudocyperus*
bicknellii	*grisea*	*radiata*
blanda	*gynandra*	*retrorsa*
brachyglossa	*gynocrates*	*richardsonii*
brevior	*haydenii*	*rosea*
bromoides	**hirta*	*rugosperma*
brunnescens	*hirtifolia*	*sartwellii*
**bushii*	*hitchcockiana*	*scabrata*
buxbaumii	*hystericina*	*schweinitzii*
canescens	*interior*	*scoparia*
careyana	*intumescens*	+*shortiana* – no acceptable voucher
cephaloidea	*jamesii*	*siccata*
cephalophora	*lacustris*	*sparganioides*
chordorrhiza	*laeviconica*	**spicata*
communis	*laevivaginata*	*sprengelii*
comosa	*lasiocarpa*	*sterilis*
+*conjuncta* – turns out to be a misidentified *stipata*	*laxiflora*	*stipata*
	**leavenworthii*	*straminea*
	leptalea	*stricta*
conoidea	*leptonervia*	*suberecta*
crawei	*limosa*	*swanii*
crawfordii	*livida* var. *radicaulis*	*tenera*
crinita	*longii*	*tetanica*
cristatella	*lupuliformis*	*tonsa*
crus-corvi	*lupulina*	*torreyi*
cryptolepis	*lurida*	*tribuloides*
cumulata	*meadii*	*trichocarpa*
davisii	*merritt-fernaldii*	*tuckermanii*
debilis var. *rudgei*	*molesta*	*typhina*
deflexa	*muhlenbergii*	*umbellata*
deweyana	*muskingumensis*	*utriculata*
diandra	**nebrascensis*	*vesicaria*
digitalis	*normalis*	*viridula*
disperma	*norvegica* ssp. *inferalpina*	*vulpinoidea*
eburnea	*oligocarpa*	*woodii*
echinata ssp. *echinata*	*oligosperma*	

invaluable to this selection, and virtually all references to species' geographic distribution are based on these maps. Those species of which at least two specimens are described by their collectors as occurring in prairie, savanna, or oak woodland were inspected with particular care. Habitats and associates information were transcribed directly from herbarium labels, studied, and summarized, then compared with other workers' studies of oak savanna and prairie sedges (cited under habitat descriptions).

I have included in this paper only those sedges that occur within the habitat delimited in the introduction to *The Tallgrass Restoration Handbook* (Packard 1997), excluding species particular to sedge meadows or wetter habitats (thus, for example, *C. stricta*), and including those of oak-dominated forests, which may in some cases harbor savanna species (cf. Packard 1988*a*). I exclude most species that appear to occur only in lowland forests, except where dominance by oaks suggests sites that may once have been lowland savannas (Hujik 1995); because of the difficulty of distinguishing between floodplain forests and savannas in the habitat descriptions on the typical herbarium label, some lowland savanna species may have been overlooked. These delimitations, like any such, are arbitrary, rooted in this case primarily in the research interests of the restorationists with whose work I am most familiar.

In several cases, the habitats of species reputed to occur in oak savanna appear in this study despite their seeming absence from Wisconsin's prairies and oak ecosystems. Such are instances in which another worker (always cited in the habitat description) has made what I judge to be a reasonable case for the species' inclusion; the habitat descriptions are still solely from WIS specimens except as specifically indicated in the text. I have not attempted an exhaustive review of the relevant ecological or taxonomic literature.

Associates are included only for sites that fall within the limits of this study. Associates should not be taken as representative of the full range of a species' habitat tolerance, but rather as examples by which to better understand the species' habitat requirements *within prairies and oak ecosystems*. The absence of associates for a given species in the list generally indicates a lack of good associate lists on WIS labels for that species as it occurs in prairies and oak ecosystems of southern Wisconsin.

Results

I recognize a total of seventy-four species as actual or probable inhabitants of Wisconsin's prairies and oak ecosystems (Checklists 1 and 2). Of these, I recommend forty-four for planting in southern Wisconsin (Table 2); of the remaining thirty, I identify seven as rare (also Checklist 1), three as exotic, and twenty as marginal or speculative denizens of prairies and oak ecosystems (Checklist 2).

The summary of habitat presence of relatively common *Carex* species (Table 2) may serve as a preliminary planting guide for restorationists working in southern Wisconsin. It is remarkable, though perhaps unsurprising, that fully half of these forty-four species may occur in wet prairie (22 species), with lowland savanna (14 species) ranking second and mesic savanna and dry to mesic oak woods tying for third (11 species). While the table is at best a crude summary of almost purely qualitative data, it is most likely a fair representation of the relative sedge diversities of the various habitats, and a confirmation of the mesophytic proclivity of the genus (cf. habitat distributions of carices listed in Curtis 1959, species list at end of book). For caveats regarding use of tables and lists as planting guides, see discussion section.

The habitat descriptions that follow (Checklists 1 and 2) represent the species' habitat distributions throughout the state, both north and south. In cases in which I hazard a prediction of a species' behavior within oak savannas, I set the prediction off clearly from the habitat as derived from herbarium specimens. Species that are rare, markedly restricted in geographic distribution, or adventive in Wisconsin are so indicated in the first line of the habitat description. Associates are presented only as they are recorded for specimens collected in prairies or oak ecosystems of southern Wisconsin.

Nomenclature throughout this paper follows the *Checklist of the vascular plants of Wisconsin* (Wetter et al., in review).

Table 2. Summary of habitats of 44 relatively common species. The following summary of habitats may be taken as a preliminary planting recommendation for restorationists working in southern Wisconsin and adjacent counties. Anyone planting the following species should first read the more complete habitat summaries in Checklist 1 and adhere to any geographic restrictions that apply; while this table does not include rare or highly restricted species, cf. Reinartz' (1997) guidelines to restoring rare or geographically restricted plant species.

Dry lime prairie
eburnea
meadii
pensylvanica – infrequently; tending toward sandier sites
richardsonii
rugosperma
umbellata

Dry sand prairie
brevior
muhlenbergii
pensylvanica
rugosperma
siccata
tonsa

Mesic prairie
bicknellii
brevior
molesta
pensylvanica

Wet prairie
brachyglossa – especially in sand
atherodes – in wet swales or standing water
bebbii
bicknellii
buxbaumii
conoidea
emoryi – alluvial soils only
haydenii
hystericina
interior
laeviconica – alluvial, especially in swales
molesta
normalis
pellita
sartwellii
scoparia – especially in disturbed, sandy soils
stipata – transitions
tenera
tetanica
trichocarpa – alluvial
vesicaria – alluvial
vulpinoidea

Dry to mesic oak woods (sugar maple not dominant)
blanda
brevior – tending toward sandier, more open woods
cephalophora
gracillima – generally on richer soils
normalis
pensylvanica
radiata
rosea
sparganioides – primarily in sugar maple forests
sprengelii – primarily in sugar maple forests

Dry savanna
brevior – not commonly
eburnea – especially *Juniperus* glades
muhlenbergii — sand
pensylvanica
rugosperma
siccata

Mesic savanna
bicknellii
blanda
brevior
cephalophora
debilis var. *rudgei*
normalis
pensylvanica
radiata
rosea
tenera
vulpinoidea

Lowland savanna
atherodes – very open, in swales or standing water
bebbii – minimal shade
bicknellii – minimal shade
emoryi – alluvial soils only
granularis – calcareous soils
laeviconica – alluvial
lupulina – generally alluvial
normalis
projecta
stipata – transitions between woods and openings
tribuloides – alluvial
trichocarpa – alluvial
vesicaria – alluvial
vulpinoidea

CHECKLIST 1
Native species of southern Wisconsin prairies and oak ecosystems

Carex albicans Willdenow *ex* Sprengel var. *emmonsii* (Dewey *ex* Torrey) J. Rettig (*C. emmonsii* Dewey *ex* Torrey)
Restricted to the bed of Glacial Lake Wisconsin. A rare and highly restricted species of low, open, sandy woods, to sphagnous woods, sandstone cliffs, and low prairies. In a sandy jack pine-scrub oak community in Wood County, it was reported as forming 50% of the ground cover, with *Carex pensylvanica, C. siccata, Gaylussacia, Lithospermum caroliniense, Lupinus, Myrica, Oryzopsis pungens, Panicum, Prunus serotina,* and *Vaccinium.* Another population of undescribed proportions was found in a pastured sand prairie/low aspen woodland in Portage County, with *Antennaria, Artemisia campestris, Viola adunca, V. labradorica, Comandra, Vaccinium, Scrophularia, Lupinus,* and *Salix.* Wilhelm characterizes this as a species of sandy woods, often associating with *Quercus velutina,* and to a lesser extent of sandy prairies and beech forests.

Carex atherodes Sprengel
Most common in standing water to two feet deep, ranging into wet, typically unshaded soil without standing water; also in cattail/bur-reed marshes, sedge meadows, willow swamps, tamarack bogs, and occasional upland areas. It was once reported in an upland forest edge and adjacent old field with low areas in Polk County; associates included *Lysimachia quadriflora, Apocynum androsaemifolium, Desmodium glutinosum, Nepeta cataria,* and *Solidago* sp. Hujik includes this in his list of lowland savanna plants, but does not analyze its sun and moisture requirements.

Carex backii Boott
***Fairly rare in Wisconsin*; vouchers are from only Oconto, Florence, Door, Dane, Juneau, and La Crosse counties. Most generally in shady habitats, on sandy soils bordering a river or creek. The species ranges in southern Wisconsin from sandy upland or hilltop oak woods (with *Quercus velutina, Q. alba*) to, less commonly, mesic or bottomland forests. In northern Wisconsin, it is more common in dry, rocky pine or oak woods, or on rock outcrops in the same. Delong and Hooper hypothesize that the species occurs in Iowa's mesic and clay-loam savannas; in Wisconsin, it seems more likely to range into open sandy woodland or sand savanna, especially adjacent to rivers.

Carex bebbii Olney *ex* Fernald
Wet-mesic to low prairies and other open wet areas, including marshes, ditches, stream edges, lake shores, and old fields; in both peaty and sandy soils; ranges occasionally to fens, marlish sand, or white cedar swamps. At a characteristic site, a low flat prairie in Kenosha County bordering Lake Michigan, the species associates with *Agrostis gigantea, Calamagrostis canadensis, Carex viridula* (common), *Scirpus pendulus, S. atrovirens, Juncus dudleyi, J. nodosus, Salix discolor, Rosa blanda, Phlox glaberrima, Calamintha arkansana, Hypericum kalmianum, Argentina anserina, Lobelia spicata, Aster lanceolatus* var. *simplex,* and *Solidago gigantea.* The species occasionally ranges into upland or, more frequently, wooded areas. It occurs often enough under sparse shade to recommend it as a potential species of very open or moderately shady lowland savanna.

Carex bicknellii **Britton**
Most common in mesic to wet-mesic prairies, but ranging from completely open prairies to moderate shade and from sedge meadows to the tops of sandy moraines. The species grows occasionally in sandy oak-hickory woods, rarely in waste areas. On a low, dry sandy ridge of the Wisconsin River floodplain terrace, dominated by very abundant *Sporobolus heterolepis*, it was found with *Andropogon gerardii, Sorghastrum nutans, Scleria triglomerata, Lepedeza capitata, Polygala verticillata* and *P. sanguinea, Veronicastrum virginicum, Eryngium yuccifolium, Prunus pumila, Euphorbia corollata,* and *Euthamia graminifolia.* It is reported from a foot off of a trail through a Walworth County white and red oak savanna, with *Trifolium pratense, T. repens, Achillea millefolium, Hypoxis hirsuta, Dodecatheon meadia, Rhus glabra.* Hujik's calculations portray it as a species of wet, distinctly shady sites within lowland savannas, though his first year's graphs (Hujik 1995, Appendix B) indicate highest frequency in high light and medium elevation. See Henderson (1995) for recommended seeding rates.

Carex blanda **Dewey**
Most common in wet-mesic, lowland, and mesic deciduous forests, especially on silt loam soils; ranging to mesic or wet-mesic savannas, brushy thickets, prairies, and open or shaded waste areas. It generally associates with such woodland species as *Quercus alba, Q. rubra, Q. macrocarpa, Carya ovata, Desmodium glutinosum, Zanthoxylum americanum, Geranium maculatum, Ceanothus americanus, Festuca subverticillata, Vitis aestivalis, Amphicarpaea bracteata, Juglans cinerea,* and *Carya cordiformis.* The species is identified by Bowles and McBride (1994) as occurring in Illinois' presettlement barrens (defined, for purposes of their work, as more or less brushy prairies on silt loam soils—"rich," "productive," fire-dependent systems grown thick with *Corylus americana* or other shrubs, *Vitis riparia, Quercus,* or other grubs); it is known from such habitats in Wisconsin as well, often with *Zanthoxylum.* This is one of our weediest species, growing in moist or shaded hollows of all kinds, garden beds, sawdust, jig tailings, roadside gravel, and split railroad ties.

Carex brachyglossa **Mackenzie**
(*Carex annectens* Bicknell)
Commonly in wet prairies and other wet sunny areas, especially where sandy; it is generally found with such wet prairie species as *Blephilia ciliata, Lilium michiganense, Phlox pilosa, Prenanthes racemosa, Silphium terebinthinaceum, Scleria triglomerata, Arnoglossum plantagineum,* and *Lobelia spicata.* The species is occasional in shaded or upland sites—collected in wooded dunes in La Crosse County and a partly wooded west slope in Iowa County, as well as a few dry sand prairies and fields—and in marsh or sedge meadow. Tolerant of disturbance.

Carex brevior **(Dewey) Mackenzie *ex* Lunell**
Mostly in sandy, dry to dry-mesic prairies; ranging into pine barrens, cedar glades, open dry to mesic oak savannas (especially with *Quercus macrocarpa,* but also sometimes with *Q. velutina*) and oak woods; occasionally in mesic soils, rarely to marshes or low prairies. The species grows readily in sand blowouts, fallow fields, road edges, suburban shrub beds, fence rows, and other such disturbed areas. Wilhelm (1995) notes that while its habitat "is a little difficult to pin down because wherever it is found there is evidence of disturbance," the species occurs in both sandy prairies and dry woods of the Indiana Dunes area. Associates of an individual collected from a dry sand prairie

in Richland County include *Aristida tuberculosa, Panicum virgatum, Digitaria cognata* var. *cognata, Schizachyrium scoparium, Eragrostis spectabilis, Koeleria macrantha, Froelichia gracilis, Lechea intermedia, Helianthemum bicknellii, Opuntia macrorhiza, Cladonia* spp., *Selaginella rupestris, Rumex acetosella, Mollugo verticillata, Lespedeza capitata, Monarda punctata, Polygala polygama, Asclepias verticillata, Oenothera biennis or parviflora, Euphorbia corollata, Erigeron annuus, Ambrosia psilostachya, Solidago nemoralis, Carex siccata, C. muhlenbergii, C. pensylvanica,* and *Cyperus lupulinus* ssp. *macilentus.* One Dane County collection was made in a dry-mesic hardwood stand under *Quercus macrocarpa* and *Carya ovata,* with *Antennaria plantaginifolia, Hypoxis hirsuta, Sisyrinchium campestre,* and *Poa palustris.*

Carex buxbaumii Wahlenberg
Open wet areas, typically calcareous, though it grows occasionally in bogs as well; most frequently in wet prairies, sedge meadows, and fens. When the species grows in the immediate vicinity of trees, it is nearly always in a boggy or sphagnous substrate (e.g., "black spruce swamp" or "tamarack bog"). One collection is from shallow standing water at the shore of Lake Michigan, in sandy crevices among dolomite gravel. Typical low prairie associates include *Hypoxis hirsuta, Phlox pilosa, P. glaberrima, Packera paupercula, Heuchera richardsonii, Hypericum kalmianum, Pentaphylloides floribunda, Lythrum alatum, Liatris pycnostachya, Solidago ptarmicoides, Solidago riddellii, S. rigida, S. ohioensis, Valeriana edulis, Oxypolis rigidior, Aster ericoides, A. novae-angliae, Thelypteris palustris* var. *pubescens, Dodecatheon meadia, Pycnanthemum virginianum, Galium obtusum* ssp. *obtusum, Krigia biflora* ssp. *biflora.*

Carex cephalophora **Muhlenberg** *ex* **Willdenow**
Most common in mesic to dry-mesic or xeric deciduous woods, but also in open areas, prairie and old field alike, and in the partial shade of *Quercus alba, Q. macrocarpa,* and other oaks; often in more disturbed areas of prairies and savannas, when present at all in those habitats (personal observation). Cheney and True (1893) cite habitat as unspecified "dry soil," in which they noticed it to be "rather common." Bowles and McBride (1994) identify this as a species of Illinois' presettlement barrens (cf. *C. blanda*).

Carex conoidea Schkuhr *ex* Willdenow
Most characteristically in wet prairies, occasionally ranging to sedge meadows, sphagnous jack pine woodlands, and wet, ruderal habitats; once collected from dry sand at a Waushara County farm. Hujik identifies this as a sedge of lowland savannas but does not give details on light or elevation tendencies. Wheeler reports that it is found (rarely) in "thinly-wooded areas" in Minnesota. Probably undercollected in Wisconsin. See associates list under *C. buxbaumii.*

Carex cumulata **(Bailey) Fernald**
***Restricted to the bed of Glacial Lake Wisconsin; rare in Wisconsin.* Generally in wet, sphagnous, sandy jack pine woods. One of our collections is from a dry oak-poplar-paper birch-maple woods atop a Jackson County bluff; another is from moist, sandy, open ground in Monroe County, with *Carex deflexa.* Wilhelm notes that while rare in the Chicago area, the species occurs more frequently in pin oak savannas of Willow Slough, Newton County (Illinois). May have occurred in presettlement lowland or perhaps upland sandy savannas and barrens *in the bed of Glacial Lake Wisconsin.*

Carex davisii Schweinitz & Torrey
***Rare in Wisconsin.* Collections have been made only in La Crosse, Trempealeau, Jackson, Columbia, and Dane counties, predominantly in alluvial forest or wet to mesic openings within the same. Of ten vouchers deposited at WIS, eight are from riverside forests or, less commonly, unshaded alluvium. Though primarily of lowland forests, its occasional presence in open or partly shaded areas suggests that this species may have grown in presettlement lowland savannas as well. Delong and Hooper (1996) identify it as frequent in oak savannas of Iowa.

Carex debilis Michaux var. *rudgei* Bailey
Concentrated in central Wisconsin (Jackson, Wood, and Portage counties especially), but ranging north to the Apostle Islands, Douglas, Oneida, and Marinette counties. Only two specimens at WIS were collected south of northern Sauk County, and only one of those from Dane County (in a second- growth oak woods). The species appears to do best under shade, in wet or moist sandy ground with a peaty component. Typical habitats in Wisconsin include sphagnous woods, bog edges, alder thickets, and low, sandy oak or pine woods; occasional in low sandy savanna, but has probably never been common in much of southern Wisconsin. The species was once collected from a sandy to peaty low prairie in Juneau County, on a site that grades to groves of *Quercus velutina* (?), *Pinus banksiana,* and *Acer rubrum,* with *Castilleja coccinea, Sorghastrum nutans, Viola lanceolata, V. sagittata.* One Marquette County collection is from a black oak woodland with *Quercus macrocarpa* and *Populus tremuloides,* in a grassy opening filled with *Rubus idaeus* var. *strigosus* and *Poa pratensis,* with *Potentilla simplex* and *Prunus serotina* seedlings.

Carex eburnea Boott
A calciphilic, wiry sedge that forms monotypic mats in open or semi-shade of sandy or limy prairies and savannas, or on exposed limestone. The species is most commonly known from cedar glades (*Juniperus* savannas) in the driftless area, though it is also found in Ashland County, Michigan Island, and in white cedar *(Thuja occidentalis)* swamps on the shore of Lake Michigan (especially Door County). Typical associates in a Pepin County cedar glade include *Amorpha canescens, Andropogon gerardii, Artemisia campestris, Asclepias viridiflora, Aster azureus, A. ericoides, A. oblongifolius, A. sericeus, Bouteloua curtipendula, B. hirsuta, Coreopsis palmata, Euphorbia corollata, Juniperus communis, J. horizontalis, Kuhnia eupatorioides, Liatris aspera, L. cylindracea, Linum sulcatum, Muhlenbergia cuspidata, M. racemosa, Mirabilis hirsuta, Dalea candida, D. purpurea, Prunus pumila, Solidago nemoralis, S. sciaphila.* One population was found atop a boulder under *Juniperus virginiana,* with *Aquilegia canadensis, Arabis lyrata, Campanula rotundifolia, Pellaea glabella,* and *Sporobolus vaginiflorus.* The species is also found in boreal forest in Door County, and occasionally at trail edges in sugar maple-red oak forest.

Carex emoryi Dewey
In wet prairies, standing water or muddy sloughs, lowland forests (frequently within openings), and occasionally on stream banks or sandbars, always in alluvial soils; associates with such species as *Calamagrostis canadensis, Glyceria striata, Iris versicolor, Onoclea sensibilis, Packera aurea.*

Carex festucacea Schkuhr *ex* Willdenow
***Extremely rare in Wisconsin.* The only specimen at WIS with useful habitat information is from Avoca prairie, a wet prairie on the Wisconsin river, where it associates with *Liatris pycnostachya, Allium canadense,* and *Thalictrum dasycarpum.* Likewise in Minnesota, the plant is known from only one location, the slightly raised banks of a river running through a lowland forest (Wheeler 1984). Rothrock, without considering individuals growing in Wisconsin, observes that *C. festucacea* "prefers moist, open woods or brush," favoring sites that are shadier than those inhabited by *C. longii,* and "soils with less sand content than typical for *C. albolutescens* and *C. longii*" (Rothrock 1991). Probably this was an uncommon denizen of low prairies and open savannas in presettlement Wisconsin.

Carex gracillima Schweinitz
Most typically in mesic or bottomland forests, often under *Acer saccharum.* Also on apparently drier sites under oak-dominated canopies (e.g., *Quercus alba, Q. velutina*), but these generally with a mesic forest element as well; usual associates include mesic forest species such as *Desmodium glutinosum, Rubus occidentalis, Festuca subverticillata, Brachyeletrum erectum,* and *Phryma leptostachya.* This common species seems to tend toward drier and occasionally more open sites in northern Wisconsin.

Carex granularis Muhlenberg *ex* Willdenow
Primarily in wet forests to moderately shady wet areas, often in disturbed calcareous substrates. The species occasionally grows in gravel roadsides, calcareous wet prairies, and fens or bog-like areas, and very occasionally in upland woods; it is extremely common in a recently disturbed lowland marl at the University of Wisconsin Arboretum in Dane County, under partial shade (personal observation). Hujik esteems this a species of lowland savannas, and it may find its way into very occasional upland savannas as well, especially on calcareous soils. For associates in a typical low prairie, see *Carex bebbii.* It is interesting to note that the type specimen of *Carex granularis* var. *haleana* was collected by T. J. Hale, with no information on the label other than "Madison, Wisconsin—1860."

Carex haydenii Dewey
Typically in marshes, sedge meadows, wet prairies, and wet waste areas; it frequently grows in soils with a sandy component. Associates from a wet prairie remnant in Rock County include *Carex bicknellii, Comandra umbellata, Dodecatheon, Houstonia caerulea, Hypoxis hirsuta, Phlox pilosa, Polemonium reptans, Sisyrinchium campestre, Zizia aurea.* Individuals are occasionally collected in riverbottom or other rich forests, wet areas within otherwise dry woodlands, or alder thickets in the north. Within Dane County, one population was reported as growing in a second-growth oak woods (Aastad et al. s.n). The species ranges mostly south of a line from Milwaukee to Oshkosh to Stevens Point and the Black River.

Carex hystericina Muhlenberg *ex* Willdenow
Very common in a variety of wet, open to barely shaded, calcareous habitats; seems to occur more often on peaty or sandy soils than in loam. Common in fens and sedge meadows, less so in conifer swamps; also on shores and along ditches and streams. Individuals occur occasionally in very wet prairies, perhaps especially those with spring-fed soils or other fresh-water flow (personal observation). Reported associates from a wet prairie in Rock County include *Gentianopsis, Betula* x *sandbergii, Cornus,* and *Larix.*

Carex interior Bailey
Almost exclusively in open, calcareous wetlands: sedge meadows, low prairies, fens. Ecology overlaps that of *Carex buxbaumii* and other wetland calciphiles. In northern Wisconsin, forma. *keweenawensis* (Herm.) Fern. may tend toward coniferous bogs and swamps, but limited collections make this difficult to know for certain.

Carex laeviconica Dewey
Uncommon in Wisconsin, where it is at the northeast edge of its range (Hujik 1995). Our populations are found in both open and wooded wet areas, slightly more frequently in the former than the latter; probably without exception on alluvial soils. Occasionally it crawls up onto roadsides or railroad embankments, which probably simulate the alluvial shores on which it naturally fares well. At Avoca Prairie on the Wisconsin River, the species is known to hybridize with *Carex trichocarpa.* Hujik describes this species as a specialist on moderately shady swales within lowland savannas.

Carex lupuliformis Sartwell *ex* Dewey
***Very rarely collected in Wisconsin*, and difficult to distinguish ecologically from *C. lupulina*, with which it co-occurs.

Carex lupulina Muhlenberg *ex* Willdenow
A species of wet to (less frequently) wet-mesic forest, rarely in adjacent wet open areas. Sometimes found in extremely wet shrubby areas, in shallow standing water, or on unshaded riverbanks; rarely in shaded uplands. The species generally grows on alluvial soils. It is known from "wet thickets" in turn-of-the-century Dane county (Cheney and True 1893). The species' occasional presence in lowland forest openings suggests that it would probably do well in shady microenvironments of lowland savannas or in wet microenvironments within drier, oak-dominated woods.

Carex meadii Dewey
Most typical of dry lime prairies, but sometimes occurs in low prairies as well, where it is easily confused with *Carex tetanica.* Occasionally found in shrubby prairies or beneath sparse oaks, and occasionally averred to grow in sandy soil as well. A typical Crawford County dry prairie collection, from the upper quarter of a steep, west-northwest-facing dolomitic hillside lists as associates: *Poa pratensis* (dominant), *Amorpha canescens, Aster ericoides, Carex richardsonii, Celastrus scandens, Comandra umbellata, Cornus racemosa, Hypoxis hirsuta, Lithospermum canescens, Pycnanthemum virginianum, Malus ioensis* var. *ioensis, Ratibida pinnata, Ribes cf. hirtellum, Sporobolus heterolepis.* The species was once collected from a shallow ditch, where it grew with *Typha latifolia, Juncus* spp., etc. See Henderson (1995) for suggested seeding rates.

Carex molesta Mackenzie *ex* Bright
Primarily in low to wet-mesic prairie, where it may be found with *Carex pellita, C. scoparia,* etc.; also in sedge meadows, wet road edges, shaded river banks, and virtually any other wet, unshaded, or moderately shady area. Grows in sandy to clay soils. Wilhelm notes that it occurs in swamps in upland woods with *Asclepias incarnata, Glyceria striata, Quercus bicolor,* and *Packera pauperculus.* While primarily of open areas in southern Wisconsin, the species probably reaches into open lowland savanna.

Carex muhlenbergii Schkuhr *ex* Willdenow
One of the most typical sedges of sand barrens, dry sand prairies, and black oak savannas; less frequently on sandstone outcrops,

sand beaches, dunes, and dry (especially sandy) oak woodlands. Tolerant of disturbance. Associates on a typical sand prairie in Richland County include *Tephrosia virginiana, Koeleria macrantha, Danthonia spicata, Monarda punctata, Achillea millefolium, Poa compressa, Ambrosia psilostachya,* and *Plantago aristata.* The species occurs rarely on lime prairies with Carex meadii. Two collectors report having found the plant in marshes, and two others report it in prairies with darker, siltier soil.

Carex normalis **Mackenzie**
Generally in moist, wooded places, though ranging to dry oak woods or wet prairies; like many species, will grade to drier locations in the shade than it will in the sun. Voss describes its usual habitat as "moist ground, damp fields, thickets, woods," with plants sometimes growing in "dry open ground." Wilhelm declares that it is "often found in mesic savannas" with associates including (among a greater number of species more typical of closed woodlands) *Rosa blanda, Veronicastrum virginicum,* and *Zizia aurea.*

Carex pellita **Muhlenberg**
(*C. lanuginosa* auct. non Michaux)
Common in wet, open or slightly wooded areas throughout southeastern Wisconsin, especially in sandy or disturbed soils; sporadic to the north and west borders of the state. The species frequently forms rhizomatous clones in wet prairies, low fields, sedge meadows and marshes, spreading readily to adjacent upland areas (as at road edges, railroad embankments, slopes leading up from lakeshores), where its vegetative shoots are frequently noticed if not usually recognized. While it is more frequently found in unshaded habitats, the species tolerates moderate shade, and reaches into upland and lowland savanna and forests; it very occasionally grows in a shady woodland. One Marquette County collection was made in a dry sand, scrubby black oak savanna, the sedge undoubtedly slowly invading from the adjacent extensive fen at the base of the slope, with *Equisetum hyemale, E. laevigatum, Carex pensylvanica, Arabis lyrata, Smilacina racemosa, Amorpha canescens, Asclepias syriaca, Galium boreale, Aster oolentangiensis, Monarda fistulosa,* and *Gaylussacia baccata.*

Carex pensylvanica **Lamark**
Most typical in dry to dry-mesic woods and prairies, especially in sand, though it ranges into sugar maple or bottomland forests as well, and very occasionally into lime prairies; one of our commonest species. In a Richland County sand prairie and thin jack pine-black oak woods, it is reported growing with *Vulpia octoflora* var. *octoflora, Hudsonia tomentosa, Koeleria macrantha, Opuntia compressa, Panicum virgatum, Rhus glabra, Selaginella rupestris,* and *Tephrosia virginiana.* Wilhelm describes this as "a common species of morainic savannas. . . . May well have been one of the principal fuel species in our timbered lands." Zimmerman similarly describes it as a species of dry prairies, barrens, and oak savannas. No effort is made here to discuss the segregate species or varieties that have been proposed for this species.

Carex projecta **Mackenzie**
Most typically in lowland or rich sugar maple forests as well as swampy thickets and shaded borders. Occasionally in lowland savanna or unshaded wet areas, though perhaps just the edges of these. Frequently in sandy soils. This species is common northward, where it occasionally strays from conifer swamps or mesic forest into bogs,

moist depressions in sand dunes, shallow standing water, or, rarely, sunny uplands. Much collected in the Apostle Islands, where it seems disproportionately frequent in open areas, perhaps due to higher humidity near the lake.

Carex radiata (Wahlenberg) Small
(*Carex rosea* Schkuhr *ex* Willd., misapplied)
In a variety of wooded stands, from bottomland forests to dry oak woods, most often in relatively mesic or wet microsites; ranges to forest edges, sparsely wooded or open fields, and, infrequently, wet or dry prairie. It is frequent under white oaks and butternuts in the University of Wisconsin Arboretum's Noe Woods, with *Carex pensylvanica, Galium triflorum, Liparis lilifolia, Circaea lutetiana* ssp. *canadensis.* The species occurs not uncommonly in shady or wet microsites of mesic oak savannas (personal observation).

Carex richardsonii R. Brown
Almost exclusively of dry, thin-soiled lime prairies, though ranging to dry sandy prairies and occasionally to calcareous wetlands. Cochrane notes that the species is "not rare, as previously thought, but undercollected due to early seasonality, poor fruiting, and resemblance to *C. pensylvanica.* L. J. Musselman and [Cochrane] have taken it on almost every dry prairie, dolomite or gravel, as well as on some sand prairies, that either has visited during the appropriate season. Like *Spiranthes magnicamporum, Solidago ptarmicoides,* and *Lithospermum canescens,* also calciphiles, this sedge is occasionally found in fens, not the type of habitat usually ascribed to it" (personal communication plus note on label of Cochrane & Cochrane #5989). See *Carex umbellata* for associates.

Carex rosea Schkuhr *ex* Willdenow
(*Carex convoluta* Mackenzie)
Very common in deciduous woods, primarily in sugar maple forests, throughout the state; also in oak woods, damp to dry, and occasionally in prairies or wet pastures; leans toward drier habitats than does the closely related *Carex radiata.* Probably both species were found in shady microsites in presettlement savannas. Associates in its typical habitat, a white oak-shagbark hickory woods in Iowa County, include *Carex hirtifolia* (abundant), *Arisaema triphyllum, Crataegus* sp., *Cynoglossum officinale, Lithospermum latifolium, Muhlenbergia schreberi, Parietaria pensylvanica, Podophyllum peltatum, Ranunculus abortivus, R. hispidus* var. *nitidus, Ribes missouriense, Sanicula canadensis, Zanthoxylum americanum.*

Carex rugosperma Mackenzie
(*C. umbellata* var. *umbellata* sensu Fernald)
Primarily of open or partly shaded sandy soils, especially dry; appears more shade tolerant than the closely related *Carex tonsa.* Usually in jack pine barrens, sand prairies, beaches and granitic outcrops, uncommon in moist hemlock woods and white cedar swamps.

Carex sartwellii Dewey
Most frequently in sedge meadow and other wet, organic soil, including bogs; more generally in alkaline than acid soils. It grows invariably in open sun or barely shaded sites, and ranges from wet prairie to standing water in marshes, ditches, lake edges. The species may be more common in wet prairies than is suggested by the infrequency of collections, as the closely studied prairies of the University of Wisconsin Arboretum have yielded the species in abundance, growing with *Stachys palustris, Anemone canadensis, Calamagrostis canadensis, Liatris pycnostachya,* and *Hierochloe odorata.*

Carex scoparia Schkuhr *ex* Willdenow
Most common in open, wet, sandy soil, occasionally in microsites that are more or less bare of other vegetation. The species ranges from shallow water (base of plant submerged) to, rarely, dry sandy uplands, and from sun to partial shade. Typical habitat includes marshes, sedge meadows, lake shores, ditches, wet prairies, sphagnum bogs; aberrant on bluffs and in upland woods. One collection was made in Iowa County in moist loamy sand, from the bottom of a disturbed moist depression in a *Quercus velutina-Pinus banksiana* woodland, with *Carex tribuloides, Cyperus strigosus, Fimbristylis autumnalis, Scirpus cyperinus, Calamagrostis canadensis, Juncus effusus, J. tenuis, Onoclea sensibilis, Thelypteris palustris, Ranunculus pensylvanicus, Potentilla simplex, Spiraea alba, Verbena hastata, Hypericum majus, Viola* sp., *Penthorum sedoides, Lycopus americanus, Lobelia inflata, Conyza canadensis* var. *canadensis, Eupatorium perfoliatum, Euthamia gymnospermoides, Bidens cernuus, Erechtites hieraciifolia, Galium tinctorium.*

Carex siccata Dewey
(*C. foenea,* misapplied)
Prominently rhizomatous; most frequent in dry sand prairies, sandy savannas (including black oak and pine barrens) or sandy woods, with such species as *Stipa spartea, Comandra umbellata, Lupinus perennis, Asclepias tuberosa, Arabis hirsuta, Lithospermum caroliniense, Coreopsis palmata, Artemisia campestris, Antennaria palinii* ssp. *fallax*, and *Lespedeza capitata.* The species ranges to mesic to wet prairie or even, very occasionally, sedge meadow. It is, for the most part, limited to the southern half of the state, with scattered individuals as far north as Douglas and Marinette counties.

Carex sparganioides Muhlenberg *ex* Willdenow
Almost exclusively in rich sugar maple and associated forests, though occasionally in slightly lower, wet forests or dry to mesic oak-dominated forests. Once found with *Poa pratensis* in an open fallow field west of Madison's University Bay, seventy feet from an oak wood. Found as well in oak leaf litter in the "Bud" Jackson School Forest, a dry-mesic southern oak forest on rolling topography, under *Quercus alba, Q. velutina,* with *Prunus serotina, Carya ovata, Q. macrocarpa, Ulmus rubra* and *Malus ioensis;* associated herbs include *Smilacina racemosa, Geum canadense, Rubus rosa, Amphicarpaea bracteata, Desmodium glutinosum, Geranium maculatum, Parthenocissus vitacea, Vitis riparia, Osmorhiza claytonii, Prunella vulgaris* ssp. *lanceolata, Circea lutetiana* ssp. *canadensis, Galium concinnum, G. circaezans* var. *hypomalacum*, and *Phryma leptostachya.*

Carex sprengelii Dewey *ex* Sprengel
Like *Carex sparganioides, C. sprengelii* grows almost exclusively in rich upland or lowland forest, with occasional individuals on rocky outcrops; rarely in full sun. Once collected in a dry-mesic forest with *Quercus alba, Populus grandidentata,* and once in a white oak-black oak-ash-shagbark hickory forest in Brown County; the latter site is perhaps drier than one in which I would expect to find *C. sprengelii* growing in southern Wisconsin. Delong and Hooper report that this species occurs infrequently in the savanna region of Iowa, where it ranges from upland woods to wet-mesic and dry-mesic prairie.

Carex stipata Muhlenberg *ex* Willdenow
Common throughout Wisconsin in a variety of moist, often shaded habitats, such as river or pond edges (especially at woodland borders), transition zones between forest and

open wetland, and the edges of logging roads or trails through low moist woods; tolerant of disturbance. Also in sedge meadows, sand flats, and transitions between open upland and open wetland. The species likely occurs at the edges of ponds, streams, and open wetlands enclosed by or abutting oak savannas. Typical associates include *Carex pellita, C. trichocarpa, Allium canadense, Ranunculus hispidus* var. *nitidus, Thalictrum dasycarpum,* and many lowland weeds.

Carex tenera Dewey
Probably most common in wet prairies with *Sporobolus heterolepis, Calamagrostis canadensis,* etc., though collections derive from a diversity of sites, ranging from mesic and dry forest to mesic or, less frequently, dry sand prairie. From a single site in Rock County, the species was collected in both a rich, wet-mesic prairie, with *Andropogon gerardii, Asclepias hirtella, A. purpurascens, Carex bicknellii, C. buxbaumii, C. umbellata, Cirsium discolor, Gentiana andrewsii, Silphium integrifolium, S. laciniatum, S. terebinthinaceum, Sorghastrum nutans*; and the mesic transition to an adjacent upland woods, with *Equisetum arvense, Poa pratensis, Carex pellita, Geranium maculatum, Helianthus grosseserratus,* and *Solidago canadensis.* Wilhelm refers to this species as one of wet to mesic savannas and their associated prairies.

Carex tetanica Schkuhr
A species of sedge meadows, wet prairies, fens, and other open wet areas, typically marly or calcareous, with such associates as *Equisetum arvense, Thalictrum dasycarpum, Pycnanthemum virginianum, Veronicastrum virginianum, Helianthus grosseseratus.* According to Theodore Cochrane, the species is frequent but undercollected. More or less limited to the southern two-thirds of eastern Wisconsin, with one collection from Trempealeau County.

***Carex tonsa* (Fernald) Bicknell**
(*Carex umbellata* var. *tonsa, C. rugosperma* var. *tonsa*)
In predominantly dry, sandy, unshaded or only slightly shady habitats; apparently more restricted in habitat than the less frequently collected *Carex rugosperma.* Typical sand prairie associates, from two Sauk County collections are *Liatris aspera, Aster ericoides, A. sericeus, A. oblongifolius, Kuhnia eupatorioides, Cyperus lupulinus* ssp. *macilentus, Hudsonia tomentosa* (rare), *Krigia virginica, Solidago nemoralis, Antennaria plantaginifolia, Opuntia macrorhiza, Panicum villosissimum, P. oligosanthes* var. *scribnerianum, Koeleria macrantha; Stipa spartea, Carex muhlenbergii, Sisyrinchium campestre, Arenaria stricta* ssp. *stricta, Viola pedatifida, V. sagittata, Calystegia sepium, Polygala polygama* var. *obtusata, Triodanis perfoliata.*

Carex torreyi Tuckerman
***This extremely rare and restricted species* is near the east edge of its range here. Specimens from far western Wisconsin and other states (from the southeast to the Rockies) come from open to shady deciduous hardwood stands. One Trempealeau County collection is from an open deciduous woods of *Quercus macrocarpa, Carya ovata,* and *Populus tremuloides* atop a high limestone hill. Another is from a rich oak forest on the slope of an esker in Waukesha County, with *Carex cephalophora, Liparis lilifolia,* and *L. loeselii.*

Carex tribuloides Wahlenberg
Primarily in riverbottom or floodplain forests, but ranging occasionally to prairie sloughs, wet fields, sedge meadows, sandbars of the Wisconsin River, and upland woodlots; rarely to dry sand. The species is most common in southwest Wisconsin (only two specimens from Dane County at WIS) and

probably more or less restricted to alluvial soils. Cheney and True (1893) note that the species was "rather common" in "low, wet places" of Dane county at the turn of the century. It may be that they confused this species with the very similar *C. projecta,* which is not restricted to floodplains; for it seems unlikely that *C. tribuloides* would be so undercollected in the low, wet places of modern Dane county. *Carex tribuloides* appears rarely in oak openings bordering marshy ground and seems a likely resident of alluvial lowland savanna.

Carex trichocarpa Muhlenberg *ex* Willdenow

Generally in open or partly shaded alluvial soils, ranging occasionally to lowland forest edges or interior. The species often forms large vegetative colonies in marshes, sedge meadows, the wettest of alluvial prairies or low weedy fields, and on the banks of streams and springs. In the transition between a marsh and wet prairie in Rock County, it is reported as associating with *Carex stricta, Salix* spp., *Phlox pilosa, Angelica atropurpurea, Cornus racemosa, Zizia aurea, Caltha palustris, Galium obtusum,* and *Silphium terebinthinaceum.* Some collections have been identified as hybrids with *Carex atherodes* (most often in cattail marshes (*fide* Cochrane) or *C. laeviconica,* the latter occupying habitats similar to those of *C. trichocarpa.*

Carex umbellata Schkuhr *ex* Willdenow (*Carex abdita* Bicknell)

Predominantly of dry lime prairies, but also on sandstone or dolomite bluffs, sand dunes, barrens, and related sites (e.g., trail edges in dry pine stands). Like other calciphiles (c.f. discussion under *C. richardsonii*), the species is occasional in calcareous wetlands (e.g., fens, sedge meadows, low prairies). Rarely in deep soil prairie. Associates from a dry prairie in Crawford County, two-thirds of the way up a steep west-northwest-facing hillside, on thin silt loam soil over Prairie du Chien (Ordovician) dolomite, are *Carex richardsonii* and *C. meadii* (both present nearby on same hillside), *Hypoxis hirsuta, Heuchera richardsonii, Comandra umbellata, Oxalis violacea, Lithospermum canescens, Hypericum* sp., *Erigeron pulchellus, Dalea candida, Rubus idaeus, Solidago missouriensis, Cirsium hillii* (many plants, generally distributed), *Triosteum aurantiacum.* See Henderson (1995) for recommended seeding rates.

Carex vesicaria Linnaeus

Sunny, wet areas, usually somewhat wetter than wet prairie—common in swales of Avoca Prairie, Iowa county—and usually on alluvial soils, these ranging from peat to sand; typically grows with such sedges as *Carex haydenii* and *C. sartwellii,* though often in wetter habitats than these two species require. Other typical habitats include lake shores, standing water, bogs and sedge meadows, ditches. Occasionally found in lowland forest edges or openings, sometimes in alluvial forests. Hujik includes this in his list of lowland savanna species.

Carex vulpinoidea Michaux

In marshes, wet forest edges, alluvial woods, lake and stream edges, and wet areas generally; often in sand, but less so than is the closely related *Carex brachyglossa.* Occasionally found in wet prairies, and once found on a sandy hillside. Infrequent in bogs and standing water.

CHECKLIST 2
Exotic, marginal, or speculative species

The following species are not native to Wisconsin, barely fall within the range of habitats delimited in the Methods section of this paper, or appear to have a proper place within these habitats despite a lack of examples among WIS specimens. In the interests of space, habitat descriptions may be cursory.

Carex albicans Willdenow *ex* Sprengel var. *albicans*
(*C. artitecta* Mackenzie)
***A very rare sedge in Wisconsin*, the only collections being from the immediate Devil's Lake area; more common south and east of us. Fernald accounts it a sedge of "dry woods and clearings." Wilhelm describes the typical locale as "dry, sandy woods, mostly in the dune region [of the Chicago region];" and Voss, similarly: "Deciduous woods of all kinds except the wettest, especially on sandy soils, in disturbed areas, along roads, and in clearings." In Wisconsin, known from dry rocky woods on the west bluff of Devil's Lake, where still extant along a path in the pines (Cochrane, personal communication), and on talus slopes around the lake.

Carex alopecoidea Tuckerman
A species of floodplain forests and open alluvium. Perhaps occasional in presettlement alluvial prairies and lowland savannas, though not represented from these habitats among recent collections. Wilhelm (1995) and Wheeler and Ownbey (1984) both describe this as a species of wet forests and meadows/fields.

Carex bromoides Schkuhr *ex* Willdenow
Primarily wet to mesic forests, occasionally to open fields, closed oak forests and, most likely, lowland savannas.

Carex bushii Mackenzie
*** Exceedingly rare, north of its historic range.* There is one known station in Wisconsin for this species; the north edge of its range passes through central Illinois. Wilhelm recognizes this as "evidently recently introduced [to Cook County] from farther south," the first collection being in 1978 and all collections being from eroded soils grown over with "weeds and non-conservative natives." According to *Flora of the Great Plains*, the species is "most common in ungrazed prairies, occasional in ditches and margins of wooded areas." This accords with our only documented site, in Iowa County: undulating terrain near a small stream course, originally high lime prairie on Dodgeville silt loam soil, actively grazed, with closest associates being *Antennaria neglecta, Cirsium hillii* (200 plants), *Erigeron strigosus, Daucus carota, Medicago lupulina, Phleum pratense, Trifolium pratense, Solidago rigida, S. speciosa,* and *Verbena stricta.*

Carex communis Bailey
Primarily a northern species, with a few populations in southern Wisconsin. Most generally of sugar maple or other mesic forests, but found once in a goat prairie, and once in what the collector considered a dry/dry-mesic forest with oaks.

Carex crinita Lamark; *C. gynandra* Schweinitz
Both primarily in bottomland forests, often alluvial. *C. gynandra* was once found at the edge of a pool in an upland oak woods, and *C. crinita* once found at the edge of a lowland woods with *Quercus bicolor*. Possibly these widespread species were formerly found in lowland savannas.

Carex cristatella Britton
Bottomland forests, marshy cornfields, sedge meadows, swales adjacent to wet prairies, one or two erratics in upland forest—but not a specimen from within good quality low prairie. The species' presence in what appears to be degraded low prairies suggests that it could easily occur in wet alluvial prairies.

Carex deweyana Schweinitz; *Carex digitalis* Willdenow; *Carex hirtifolia* Mackenzie
All three are found primarily in sugar maple forest, and range only rarely into oak-dominated forests.

Carex gravida Bailey
***Apparently adventive from the west.* This species is considered by Cochrane and Zimmerman to be adventive from prairies of the Great Plains, where it is common (Cochrane, personal communication). There is one record—no habitat information, label reading only "Madison, Wisconsin"—from 1861; the next specimens were collected in the 1930s. The species is most frequently found in open disturbed habitats —roadsides, railroad beds, ditches, etc.—but is very occasionally found in prairies as well, especially dry, ranging very infrequently to wet prairies, marshes, fens and lake edges, and forest edges.

Carex grisea Wahlenberg
(*C. amphibola* Steud. var. *turgida* Fernald, misapplied)
Primarily of mesic to lowland, often alluvial forests. Some specimens occur in open deciduous forests or lowland forest with *Quercus bicolor*, perhaps supporting McCarty's observation that in Missouri this is a relatively conservative species on closed and usually mesic fire-dependent sites (McCarty in press). Perhaps a lowland savanna species in Wisconsin.

Carex intumescens Rudge
Most typical of moist to wet woodlands. Collected once in a dry oak-hickory woods in Columbia County.

Carex lacustris Willdenow
Appears not to grade into wet prairies (more typical of sedge meadows, marshes, and other such wet habitats), but certainly in sloughs within wet prairies.

Carex lasiocarpa Ehrhart
Typically found in sedge meadows, sphagnum bogs, marshes, and lake edges, often in shallow water. Very rarely in the wettest of prairies.

Carex leavenworthii Dewey
***Very local in Wisconsin, where apparently adventive*, its native range being to the south. The bulk of Wisconsin collections come from a single location, a "weedy lawn" at the base of Science Hall on the UW-Madison campus's Bascom Hill, where the first collection of the species from the state was made in 1957; the population there is now extirpated. This site, in a region of former oak savanna, and a second collection from a lawn shaded partly by *Quercus macrocarpa* accord with Delong and Hooper's assessment of the species as a denizen of "prairie, woodlands, wooded bluffs" and mesic/clay loam oak savanna.

Carex merritt-fernaldii Mackenzie
Infrequent in Wisconsin, slightly more common northward. Usually in low, sandy, open disturbed areas, rarely in open woodlands. This species might have been present in disturbed areas of low sand prairies before settlement.

Carex muskingumensis Schweinitz
Always on alluvial soils, chiefly along the Wolf, Wisconsin, and Mississippi Rivers; primarily of lowland forests and transition zones. Once recorded from a "*Carex* spp. bog or marsh" at the edge of a bottomland woods with *Quercus bicolor* (Iltis #6058). Other than this, it apparently has been found only in shade, but it might occasionally grade into shady lowland savanna.

Carex swanii (Fernald) Mackenzie
** *This is one of Wisconsin's rarest sedges* (four collections at WIS, three of which are from the southeast corner of the state), probably at the northwest extent of its range here. Wilhelm describes it as "a characteristic species of black oak savannas in our eastern and southern sectors," but WIS specimens are from a Waushara County alder thicket, a sandy roadside in Kenosha County, and a sugar maple forest in Waukesha County. In other prairie-province states, *C. swanii* has been found in rich, rocky soil beneath a thick oak-hickory canopy (LeFlore County, Oklahoma), in a prairie slough (Winnebago County, Illinois), and in a dry, sandy logging road through a forest clearing (St. Joseph County, Indiana). This species may have occasionally found its way into sandy oak savannas before settlement, though its seeming absence from sand savanna remnants and its extreme rarity in Wisconsin render this doubtful.

Carex tuckermanii Dewey
Primarily in wet shaded woods, generally on alluvial soils, occasionally in unshaded sloughs, river banks, and wet pastures as well, and at the edges of pools in alluvial or otherwise wet woodlands. In the north, often ranges to wet hardwood forests, and sometimes to conifer bogs, alder thickets, cedar swamps, marshes and wet grasslands. This species may be occasional in very shady lowland savannas, though such placement is not strictly supported by vouchers inspected.

Carex typhina Michaux
A plant of floodplain forests, frequently growing with *Quercus bicolor.* This species may occasionally move into lowland savanna.

Carex viridula Michaux
Primarily of wet sandy or rocky shores, calcareous wetlands, and adjacent communities. Thus collected once in a wet prairie adjacent to Lake Michigan (Kenosha County, Cochrane et al. #11,279). Schneider (1994) found this in a quarter of the Ohio fens that he studied, and he accounts it, with *Carex interior,* an obligate calciphile.

Discussion

Those who plan to utilize these checklists and Table 2 as planting guidelines should interpret the data with some care. The portrayals of species' environmental requirements in this paper generally do not adequately represent the full range of their tolerance and preferences across the range of environments present in Wisconsin; *Carex richardsonii* and *C. tetanica,* for instance, are sufficiently undercollected that the breadth of their behavior in Wisconsin prairies may not be well understood. Conversely, the ecology of some species pairs with markedly overlapping habitats, such as Carex meadii and C. richardsonii, tend to resemble one another less than the habitat narratives in this paper suggest. As is the case worldwide, work on Wisconsin carices suffers from a lack of knowledge of the species' autecology (Catling et al. 1990). Experimental plantings and more sophisticated empirical studies are required to both differentiate and sufficiently represent the habitat requirements within this genus (cf. Jordan et al. 1987, Leach 1996).

The distributions of a few species in this study seem to support Bray's hypothesis (1958) that species of wet to wet-mesic prairies may move into shady sites of somewhat drier uplands; *Carex bicknellii*, *C. normalis*, *C. tenera*, and *C. vulpinoidea*, for example, all occur in both wet (open) prairies and mesic to dry oak woods and savannas. On a larger scale, a few species exhibit trends in habitat requirements that support the observation that several forest species of south-central Illinois grade into more open savanna toward the north and east, particularly in Wisconsin (Delong and Hooper 1996). In particular, *Carex gracillima*, *C. pedunculata*, and *C. sprengelii* appear to gravitate toward more open and perhaps drier habitats as they move northward. Such geographic and habitat shifts surely affect other species as well. Restorationists, many of whom are already fully conscious of these trends, can contribute greatly to the fine discrimination of species habitats through experimental plantings and close observation.

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Richard S. King

Dispersal of Karner Blue Butterflies (Lycaeides melissa samuelis *Nabokov) at Necedah National Wildlife Refuge*

Abstract *Mark-release-recapture research was conducted to determine dispersal ability and patterns of the Karner blue butterfly* (Lycaeides melissa samuelis *Nabokov). Karner blue butterflies were marked during the first and second flights of the 1995 field season. Two hundred and three individuals were marked during the first flight, and 1,236 were marked during the second flight. The mean distance traveled by males between locations was 456.9 m and 214.7 m during the first and second flights, respectively. The mean distance traveled by females between locations was 69.8 m during the first flight and 359.2 m during the second flight. Inter-site dispersers (those individuals dispersing ≥ 1,150 m to new sites) represented 7.4% and 11.2% of the recaptures during the first and second flights respectively. Only one individual (0.07%) was located on a road corridor between suitable habitat patches. The percentage of individuals making inter-site dispersals was markedly different between sexes and among individual sites. Wind direction had no detectable effect on emigration rates for any of the sites, although significant differences in immigration rates were detected among wind directions. The observed dispersal trends indicate that Karner blue butterflies were able to disperse substantial distances (> 1,150 m) frequently and that they rarely use corridors to do so.*

Range-wide population declines of the Karner blue butterfly (*Lycaeides melissa samuelis* Nabokov) led to its listing as an endangered species in December 1992 (Clough 1992). Despite being one of the most studied butterflies of North America (Dirig 1994), many information gaps exist regarding the ecology of the Karner blue butterfly (Andow et al. 1994). One of the most fundamental information gaps concerns movements and dispersal of individual butterflies within and among populations. Karner blue butterfly populations are generally assumed to have metapopulation dynamics (Givnish et al. 1988). However, reviews of metapopulation literature reveal that data supporting critical assumptions of metapopulation theory are lacking for any species (Harrison 1991). Central to metapopulation dynamics theory is dispersal of organisms between patches (Hanski 1991).

Few studies focusing on the dispersal of Karner blue butterflies have been conducted. A limitation common to all insect dispersal research to date is the issue of decreasing probability of detection with increasing dispersal distances (Premo et al. 1994). All Karner blue butterfly dispersal studies to date fall into two major categories: studies conducted on corridors (Lawrence and Cook 1989, Sfera et al. 1993, Bidwell, unpublished data) and studies conducted in forested landscapes with Karner blue butterfly habitat patches (Fried 1987, Packer 1987, Welch 1993). Without knowledge of individual Karner blue butterfly movements and dispersal, development of management plans aimed at safeguarding this species will lack an important foundation.

Methods

This study was conducted during June, July, and August (the Karner blue butterfly's first and second flight periods) of 1995 on three populations on the Necedah National Wildlife Refuge (NNWR) in south-central Wisconsin (48°83′N, 90°10′W) (Figure 1). All populations are on restored oak barrens habitat (Curtis 1959) and are separated from each other by 1,150, 1,550, and 2,250 m of unsuitable habitat. Unsuitable habitat included water impoundments and wetlands void of nectar sources and wild lupine *(Lupinus perennis)* (the Karner blue butterfly's only known larval food source). The populations all lie within an area dominated by an open landscape with oak barrens and wet meadow habitats abutting large water impoundments.

Mark-release-recapture (MRR) was conducted throughout the entire study site every day of the first and second flight periods regardless of weather conditions. MRR began at 0800 and ended at 1530. The study area was staked with 50 m x 50 m grids that provided a reference to geographic location. The grid system also was used to keep search effort equal throughout the study area. Equal time was spent in each 50 m x 50 m cell every day. This decreased the number of butterflies that were captured but reduced bias toward what observers considered suitable habitat. Butterflies were captured with standard aerial butterfly nets, and individuals were given a unique three digit number on their hind-wing with an ultra-fine point "Sharpy" marker. Individuals were released immediately after marking was completed. The entire procedure usually took approximately 15 seconds, and no mortalities were observed during the study. The location, condition, and sex of each individual were recorded as well as date and time.

Data Analysis

Mean-distance-per-move (MDM) (average of all distances between locations), mean-distance-moved-per-day (MDD) (distance moved, divided by the number of days since the last location), total-distance-moved (TDM) (the sum of all linear distances between locations) and range-length (RL) (linear distance between the two most distant locations) were determined for male and female Karner blue butterflies during the first and second flights.

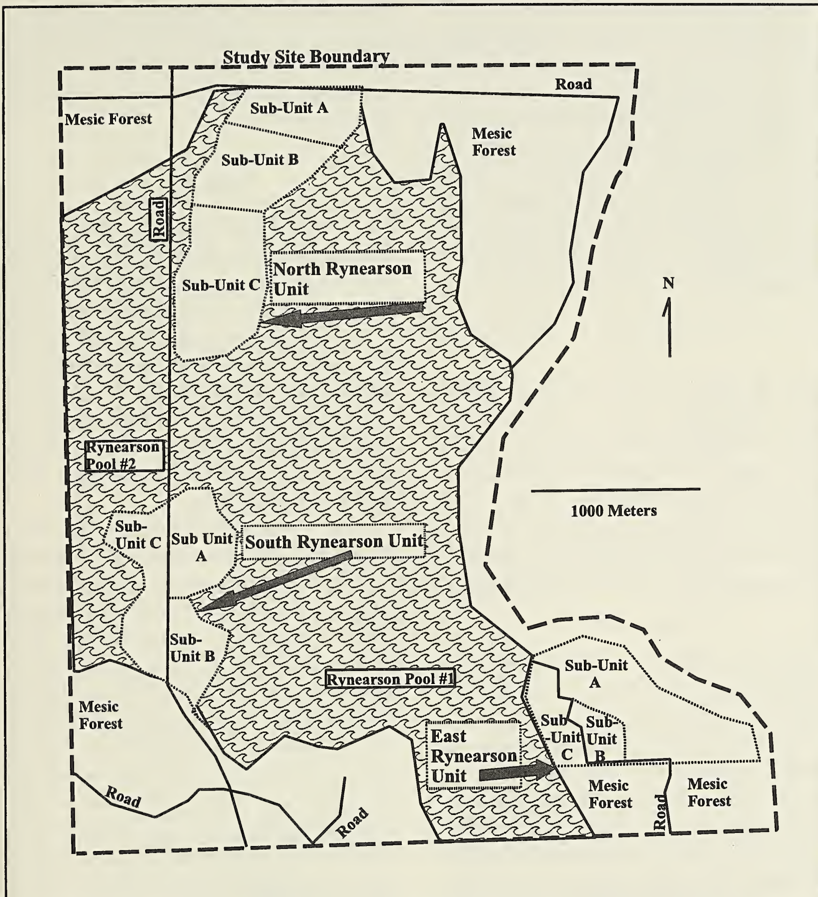

Figure 1. Location of units and sub-units within study area boundary on Necedah National Wildlife Refuge, Juneau County, Wisconsin.

All population parameters were estimated using mark-release-recapture data. Population size (P_i), total number of new animals entering the population (B_i), and survival probability (F) were determined as outlined by Pollock et al. (1990) using the using the software "Jolly." The total number of individuals emigrating (E_i) and immigrating (I_i) was determined from the dispersal data. The total number of emigrating individuals dispersing from a site was estimated as:

$$E_i = \frac{m'_{i+1}}{m_i} P_i$$

where m_i is the number of animals marked in the ith sample and m'_{i+1} is the number of those individuals that disperse out of the unit by the I + 1th sample. Individuals were assumed to have emigrated on the I - 1th sample that they were observed on a different site. The number of individuals immigrating into a unit was estimated as:

$$I_i = Ea_{(I-1)} + Eb_{(I-1)}$$

where Ea_{i-1} and Eb_{i-1} are the number of individuals dispersing to that site from the two other sites in the study area.

Wind direction was determined daily at 1300 (generally when maximum winds occurred) with a weather station (Forest Technology Systems, Bellingham, Washington). The weather station recorded wind direction in degrees. These data where then converted into eight classes (N, NW, W, SW, S, SE, E, NE) for analysis.

A chi-square analysis was used to test for differences in the proportion of individuals making inter-site dispersals (dispersal > 1,500 m) between sexes and among units. A Kruskal-Wallis test was used to test for differences in the distributions of dispersal between the sexes and flights. A Kruskal-Wallis test was also used to test for differences in the distributions of the emigration and immigration data among wind directions. Means are reported ± SE. The results of statistical procedures were regarded significant at $P \leq 0.1$.

Results

Two hundred and three individuals were marked during the first flight and 1,236 were marked during the second flight. Recapture rates with data pooled by sex were 11.7% and 25.7% for the first and second flights respectively, which were significantly different ($\chi^2 = 21.64$, df = 1, $P = 0.0012$). The male recapture rate (25.8%) was significantly greater ($\chi^2 = 3.91$, df = 1, $P = 0.05$) than that for females (21.9%) with data pooled over the flights.

Inter-site dispersal (movements between sites) (ISD) represented 7.4% and 11.2% of the recaptures on the entire study area during the first and second flights respectively. Individuals first located on the East Rynearson site had the highest proportion of individuals making ISD (40.0%). The proportion of Karner blue butterflies making ISD was 22.4% and 6.1% for individuals first located on the South and North Rynearson Sites respectively (Figure 2). The proportions of individuals making ISD from the three sites were significantly different ($\chi^2 = 41.21$, df = 2, $P = 0.001$). Of all females, 15.3% made at least one ISD, which was significantly more ($\chi^2 = 5.46$, df = 1, $P = 0.02$) than for males (7.9%) (Table 1).

When pooling data by flight, males moved significantly less between locations than females ($\chi^2 = 6.99$, df = 1, $P = 0.008$). Mean-distance-per-move (MDM) for first flight males (456.9 ± 261.7 m) was not significantly more ($\chi^2 = 0.61$, df = 1, $P = 0.44$) than that for second flight males ($\bar{x}$ =214.7

Figure 2. Emigration and immigration rates by day on the three populations studies during the second flight of 1995, on Necedah National Wildlife Refuge, Juneau County, Wisconsin.

Table 1. Summary of the number of individuals captured and recaptured by sex and flight during 1995 on Necedah National Wildlife Refuge, Juneau County, Wisconsin.

	♀	♂	*First Flight*	*Second Flight*
Number of individuals marked	674	765	203	1,236
Number of indivuduals recaptured	189	266	27	428
Recapture percentage	21.9	25.8	11.7	25.7
ISD	15.3	7.9	7.4	11.2

Recapture percentage represents the precent of individuals reptured on at least one occasion.
ISD = the percentage of individuals making at least one inter-site dispersal (≥ 1,500 m).

Table 2. Summary of dispersal statistics ($\bar{x} \pm$ SE) for Karner blue butterflies during the first and second flights of 1995 on Necedah National Wildlife Refuge, Juneau County, Wisconsin.

	♀	♂
First flight		
MDM	69.8 ± 17.5	456.9 ± 261.7
TDM	74.4 ± 5.0	456.9 ± 261.9
DBR	1.4 ± 0.3	2.6 ± 0.1
MDD	48.2 ± 12.1	108.6 ± 32.7
RL	73.3 ± 13.8	457.0 ± 261.9
Second flight		
MDM	359.2 ± 27.3	214.7 ± 30.8
TDM	433.1 ± 72.8	277.1 ± 39.7
DBR	3.3 ± 0.3	2.5 ± 0.2
MDD	173.2 ± 13.1	119.5 ± 7.5
RL	613.7 ± 167.1	373.6 ± 98.6

MDM = mean distance between all locations.
TDM = sum of all distance between locations.
DBR = days between recapture.
MDD = mean distance traveled divided by the number of days between locations.
RL = maximum distance between any two locations.

± 30.8 m). MDM for first flight females (69.8 ± 17.5 m) was significantly less (χ^2 = 3.28, df = 1, P = 0.07) than that for second flight females (359.2 ± 27.3 m) (Table 2).

Taking elapsed time into consideration (mean-distance-moved-per-day), females did not move significantly (χ^2 = 1.55, df = 1, P = 0.21) further than males when pooling data by flight. MDD was 108.6 ± 32.7 m and 119.5 ±7.5 m for males during the first and second flight, respectively, which was not significantly different (χ^2 = 1.97, df = 1, P = 0.16). Female MDD was also not significantly different (χ^2 = 0.26, df = 1, P = 0.61) between the first ($\bar{x}$ = 48.2 ± 12.1 m) and second ($\bar{x}$ = 173.2 ± 13.1 m) flights (Table 2).

Days-between-recapture (DBR) (the days between original and subsequent recaptures) was significantly different (χ^2 = 3.50, df = 1, P = 0.06) for males and females, which explains the discrepancies that were observed between the MDM and MDD data. First flight male DBR ($\bar{x}$ = 2.6 ± 0.1) was nearly identical to the second flight male DBR ($\bar{x}$ = 2.5 ± 0.2) with no significant difference

(χ^2 = 0.001, df = 1, P = 0.98). Spacing between recaptures was significantly (χ^2 = 6.27, df = 1, P = 0.01) greater for second flight females ($\bar{x}$ = 3.3 ± 0.3) than first flight females ($\bar{x}$ = 1.4 ± 0.3). Unlike the MDM and MDD data, a significant difference (χ^2 = 3.26, df = 1, P = 0.07) in the DBR data was detected between the flights with data pooled by sex (Table 2).

The maximum distance between any two locations (range-length) was also significantly different between the flights (χ^2 = 5.03, df = 1, P = 0.03) with data pooled by sex. RL was not significantly different (χ^2 = 0.02, df = 1, P = 0.90) between the sexes when the flights were pooled. Mean RL was 73.3 ± 13.8 m and 613.7 ± 167.1 for first and second flight females respectively, which was significantly different (χ^2 = 5.17, df = 1, P = 0.02). First flight male RL ($\bar{x}$ = 457.0 ± 261.9 m) was not significantly different (χ^2 = 0.40, df = 1, P = 0.53) than the second flight male RL ($\bar{x}$ =373.6 ± 98.6 m) (Table 2).

The total-distance-moved (TDM) was not significantly different between the sexes and flights. TDM was significantly shorter (χ^2 = 4.67, df = 1, P = 0.03) between the first ($\bar{x}$ =74.4 ± 5.0 m) and second ($\bar{x}$ = 433.1 ± 72.8 m) flights for females. First flight male TDM ($\bar{x}$ = 456.9 ± 261.9 m) was not significantly greater (χ^2 = 0.001, df = 1, P = 0.92) than second flight male TDM ($\bar{x}$ = 277.1 ± 39.7 m) (Table 2).

Emigration rates were not significantly different among wind directions for any site, but immigration rates differed significantly (χ^2 = 9.55, df = 4, P = 0.05) among wind directions on the South Rynearson Site. Similar results were seen on the North Rynearson Site with immigration rates being significantly different (χ^2 = 8.05, df = 4, P = 0.09) among wind directions. Immigration to the North and South Rynearson sites peaked on days with a west wind (Table 3). Sample size was too small for analysis of the East Rynearson immigration data.

Discussion

Karner blue butterflies studied on the NNWR were able to move large distances (>1,150 m), and exchange of individuals among the populations was frequent. Approximately 11% of all individuals marked during the second flight were eventually recaptured at sites other than their original capture site (Table 1). Distances between locations in excess of 1,500 m were common (7.5%, n = 429). Limitations in the study design necessitate viewing these figures as minimums. Although particular effort was given to detect the long-range dispersers during this study, Karner blue butterflies could have dispersed outside of the study area boundary. If detected, these long range dispersers would

Table 3. Immigration rates (reported as percent ($\bar{x}$ ± SE) of population estimated to have originated at a different site) for Karner blue butterflies during the second flight of 1995 on Necedah National Wildlife Refuge, Juneau County, Wisconsin.

	Wind Direction				
Population	*Northwest*	*South*	*West*	*Northeast*	*Southeast*
South Rynearson	0.0 ± 0.0	0.1 ± 0.1	10.8 ± 7.6	1.5 ± 1.1	8.3 ± 4.2
North Rynearson	1.2 ± 0.7	2.0 ± 1.2	6.3 ± 4.5	0.6 ± 0.4	0.8 ± 0.4

Sample size was too small for the East Rynearson site to permit analysis of immigration rate data.

have increased the means of all the summary statistics. Also, limitations of the study design may have lowered the percentage of individuals observed making movements in excess of 1,500 m. MRR was conducted over a large study area to make the study sensitive to long distance dispersals. The cost of this approach was that most individuals were relocated only once. If MRR had been conducted only in the areas of highest concentration, the recapture rate and summary statistics may have been higher. Of the individuals that were located greater than three times, movements in excess of 1,500 m were even more common (8.5%, n = 354).

Exchange of individuals among populations required that individuals crossed ≥ 1,150 m of unsuitable (nectarless) habitat. How this exchange occurred is unknown. Of the 1,439 individuals that were marked during the first and second flights, only one (0.07%) was located on a road corridor connecting the populations while a full 11.0% of the individuals made at least one inter-site dispersal. Use of roadsides as corridors can be assumed to be negligible given that the roadsides received as much search effort as any other part of the study area. Prevailing wind does not provide an answer either. Wind direction was a poor indicator of emigration rates. Immigration rates, the rate of individuals dispersing to a site, appeared to be related to wind direction for the South and North Rynearson sites (Figure 1). However, it can be assumed that butterflies were not passively carried by wind to these sites. Neither the North nor South Rynearson sites had a population source to the immediate west, and yet immigration to both those sites peaked on days with a west wind. Therefore, most of the immigration occurred against prevailing winds.

All summary statistics indicate females travel greater distances than males during the second flight. The opposite was true for the first flight, which could be a function of small sample size. When pooling data by flight, females (15.3%) were more likely to make one inter-site dispersal of 1,150 m or more than were males (7.9%) (Table 1). The recapture ratio (1:1.2 females to males) and the significant difference between the sexes in days-between-recapture (DBR) data suggest that catchability and/or detectability between the sexes may vary greatly with Karner blue butterflies. Therefore, as with many invertebrate species (Carothers 1973; Begon 1979; Tabashnik 1980; Gall 1984*a*, 1984*b*; Murphy et al. 1986), it would be advisable to determine population estimates separately for each sex when using mark-release-recapture methods. Differences in detectability also could affect population estimates of Karner blue butterflies when using methods other than mark-release-recapture.

All butterflies, regardless of sex, flight, and population source, were able to move around the study site easily. The study site is atypical of Wisconsin's Karner blue butterfly habitat. Open canopy uplands and wetlands comprised the entire study site. Typically, Karner blue butterfly populations are separated by closed canopy forests. Although road corridors did not enhance dispersal during this study, they could aid dispersal through closed canopy forests. During this study, all dispersals between sites occurred across unsuitable habitat that had no nectar sources. The presence of nectar sources between the sites could have enhanced inter-site dispersal. Further research is needed to determine how Karner blue butterfly dispersal is affected by nectar sources between sites and the presence of corridors in closed canopy landscapes.

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Woody Vegetation Survey of Sibley Burr Oak Grove Nature Preserve, Ford County, Illinois

Abstract *Densities, basal areas, and average diameters were determined for the woody overstory at Sibley Burr Oak Grove, Ford County, Illinois. Consisting of two groves originally separated by a lake and a sedge meadow, the woods consisted almost entirely of bur oaks; only two other species with a total of 10 individuals entered the canopy. In the largest area (13.75 ha) the bur oaks averaged 69.9 cm dbh, had a density of 38.8 stems/ha, and a basal area of 16.33 m²/ha. Most trees had broad, open-grown crowns characterized by 2–7 main branches and low branches or branch scars within a few meters of the ground. More than 60 bur oaks exceeded 100 cm dbh. The structure, size, and open-grown nature of the trees indicates that the grove was a savanna or open woodland prior to European settlement in the 1860s.*

Prairie groves on morainal ridges were common in the Grand Prairie Division of central Illinois in early settlement times (Schwegman 1973). These groves were particularly common in the headwaters region of east-central Illinois in Ford County, (Headwaters Region Map 1871), where five river systems have their origins (Figure 1). Numerous ponds, sloughs, sedge meadows, and other wetland communities occurred between the morainal ridges. Some of these ridges supported small groves dominated by *Quercus macrocarpa* Michx. (bur oak). These "bur oak openings" existed because fires would not carry across these wetlands in most years (Stout 1946). High intensity fires undoubtedly burned through these wetlands and groves in drought years.

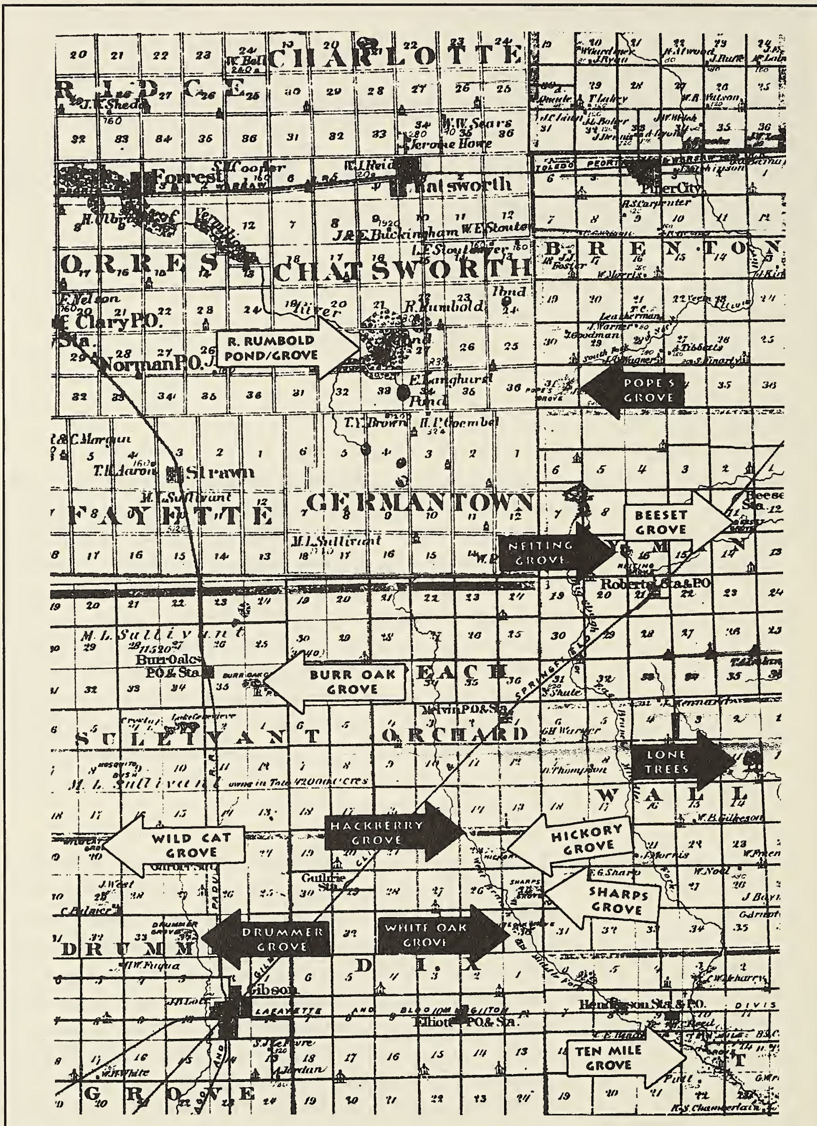

Figure 1. Prairie groves of the headwaters region of central Illinois in 1871 (Headwaters Region Map 1871).

Much of the prairie in Illinois, Indiana and Ohio probably would have been replaced by forest if not for the extensive fires that regularly burned across these states (Gleason 1912, 1913; McClain and Elzinga 1994). Most grasses and forbs were not adversely affected by these fires, which occurred mostly in late fall and sometimes in early spring. In contrast, most woody species, particularly young individuals and species with thin bark, were easily killed (Anderson 1983, Ebinger 1986, Ebinger and McClain 1991). Resprouting of top-killed individuals was common, but sprouts and damaged individuals were also more susceptible to future fires and predator damage (Hruska and Ebinger 1995).

Most of the prairie groves associated with morainal ridges have been destroyed. One of the few remaining examples is located near Sibley, Ford County, Illinois. This study was undertaken to determine the composition and structure of the overstory vegetation at the Sibley Burr Oak Grove.

Description of the Study Area

Located 1.5 km southeast of Sibley in western Ford County, Illinois, Sibley Burr Oak Grove Nature Preserve lies within the Grand Prairie Section of the Grand Prairie Division (Schwegman 1973). This grove (S 35 & 36 T25N R7E), located on a ridge and not associated with any stream, was described on November 29, 1823, by Elias Rector, a Government Land Office (GLO) surveyor, as an oak-hickory forest with an undergrowth of hazel (GLO field notes Vols. 231, 243 and 343).

The grove is 252 m above sea level with a local relief of 4 m. The soils of the grove have developed on shallow loess (less than 1 m thick) on calcareous glacial till of Wisconsin age. These Blount Silt Loams, which occur on nearly level ground, are somewhat poorly drained and occur as irregular areas at higher elevations on moraines. The available water holding capacity and organic content are both moderate, while the depth of the seasonal water table is more than 1 m (Fehrenbacher 1990).

European settlement of the Sibley area began in 1860 when Michael Sullivant purchased 40,000 acres around the grove and started a farming operation. Originally, the village of Burr Oak was located in the grove, but it was moved about 1.5 km to the northwest in 1868 to be adjacent to the Illinois Central Railroad. During Sullivant's occupancy, Burr Oak Farms was the world's largest farm and was featured in *Harper's Weekly Magazine* in 1871. Due to two consecutive droughts Michael Sullivant was forced to sell, and by 1879 Hiram Sibley owned the farm. At that time the town's name was changed to Sibley. From the 1860s until 1930 the grove was used as a staging area for farming operations and for the grazing of livestock. From 1930 until 1960 the grove was part of a hog farm operation, hogs being allowed to roam throughout the woods. After 1960 the grove was not grazed, resulting in the development of a dense understory of *Crataegus mollis* (Torrey & Gray) Scheele (red haw), *Prunus serotina* Ehrh. (black cherry), *Maclura pomifera* (Raf.) Schneider, and *Celtis occidentalis* L. (hackberry). In the fall of 1995 the grove was donated to The Nature Conservancy, and restoration efforts were started.

At the present time the grove consisted of two tracts, an eastern tract of 13.75 ha (34 acres), and a small western tract of 1.62 ha (4 acres). Between the two was a cultivated field about 50 m wide, that, according to early records, was originally a small pond and sedge meadow. Presently the exotic and weedy woody understory species have been removed from the grove, and parts of the grove have been subjected to ground fires. The small pond and sedge meadow that originally existed between the two tracts have been restored. This involved the removal of 65 cm of mineral soil that had accumulated over the original Houghton Muck.

Materials and Methods

The number, size, and species of all living and dead standing canopy and subcanopy species (25 cm dbh and above) were recorded during the summer of 1996. From these data the relative dominance, relative density, importance value (IV), average diameter (cm), density (stems/ha) in broad diameter classes, and the basal area (m^2/ha) were calculated for each species. The IV determination is the sum of the relative values for each species with a total possible of 200 (McIntosh 1957). The percent cover was determined by photographing the canopy from below (16 points) and calculating the percent of the area covered using a 100 point dot matrix. Nomenclature follows Mohlenbrock (1986).

Results and Discussion

Of the 661 canopy and subcanopy trees recorded in the grove, 651 were bur oaks (*Quercus macrocarpa* Michx.), nine were black walnut (*Juglans nigra* L.), and one was a white oak (*Q. alba* L.) (Table 1). Bur oaks, which dominated all diameter classes, were characterized by open-grown crowns having 2–7 main crown branches (Table 2). Most individuals had low branches or branch scars; the first branch or large branch scar averaged 3.3 m above the ground. Bur oak diameters ranged from 30.0 to 139.9 cm dbh. There were 170 bur oaks that had diameters greater than 80 cm, and 61 that had diameters in excess of 100 cm dbh. No attempt was made to age the living bur oaks, but one dead individual, with a dbh of 96 cm, was aged at 330 years.

The data on the two separate tracts of the grove (east and west areas) were kept separate (Table 1). The 13.75 ha eastern tract had an average of 39.34 stems/ha, and a basal area of 16.59 m^2/ha. The average diameter of bur oaks was nearly 70 cm, with 2.4 stems/ha less than 40 cm dbh, and 4.07 stems/ha above 100 cm dbh. The small western tract (1.61 ha in size) had a average of 74.08 stems/ha, and a basal area of 24.75 m^2/ha. Here the average diameter of bur oaks was nearly 63 cm dbh, with over 71 stems/ha being less than 80 cm dbh. In this section the canopy was essentially closed with 85% cover, while the eastern section was more open with 67% cover.

The dense understory of red haw, black cherry, and hackberry was removed during the past two years. Tree rings of cut stumps indicate that both red haw and osage orange were present in the preserve more than 90 years ago. In contrast, the other understory exotic and weedy woody species have only been present for the past 35 years, after the hog operation ceased. Bur oak seedlings were occasionally encountered in unburned parts of the grove, but very few saplings of this species were found.

Most of the prairie groves found in central Illinois are associated with streams and rivers. These streamside groves are usually large; many are more than 5 square miles in size. They also have a high woody species diversity with more than 20 species reaching the canopy. Most of these groves have high densities of *Acer saccharum* Marsh. (sugar maple) and other thin-barked, fire-sensitive species. Oak and hickories are present, and except for white oak, have low

Table 1. Diameter classes, relative values, importance values and average diameters of the woody overstory species at the Sibley Burr Oak Grove Nature Preserve, Ford County, Illinois.

	Stems/ha by Diameter Classes (cm)							Basal				Average
								Area	Relative	Relative		Diameter
Species	*<40*	*40–59*	*60–79*	*80–99*	*100–119*	*120+*	*Total*	*m²/ha*	*Density*	*Dom.*	*IV*	*(cm)*
East area— 13.75 ha (34 acres)												
Bur oak	2.40	13.60	11.71	6.98	2.76	1.31	38.76	16.33	98.5	98.5	197.0	69.9
Black walnut	—	0.15	0.07	0.29	—	—	0.51	0.24	1.3	1.4	2.7	75.3
White oak	—	0.07	—	—	—	—	0.07	0.02	0.2	0.1	0.3	51.3
Totals	2.40	13.82	11.78	7.27	2.76	1.31	39.34	16.59	100.0	100.0	200.0	
West area— 1.62 ha (4 acres)												
Bur oak	5.56	30.86	25.31	8.03	1.85	1.23	72.84	24.37	98.3	98.5	196.8	62.9
Black walnut	—	0.62	0.62	—	—	—	1.24	0.38	1.7	1.5	3.2	62.3
Totals	5.56	31.48	25.93	8.03	1.85	1.23	74.08	24.75	100.0	100.0	200.0	

Table 2. Average crown diameters (m) by broad diameter classes of the bur oaks at the Sibley Burr Oak Grove Nature Preserve, Ford County, Illinois.

Diameter Classes (cm)	*Number Examined*	*Average Crown Diameter (m)*
40.0–59.9	20	13.03
60.0–79.9	24	19.07
80.0–99.9	40	20.14
100.0–119.9	17	21.91
120.0–139.9	8	23.20

IV's, bur oak being a minor component (Boggess 1964, Boggess and Bailey 1964, Boggess and Geis 1966). In contrast, Sibley Burr Oak Grove has only three canopy species with bur oak being, by far, the leading dominant (Table 1). Its overstory closely resembles that of the bur oak openings of Wisconsin, Minnesota, and Michigan (Stout 1946, Curtis 1959).

Sibley Grove is but one of the many groves, consisting primarily of bur oak, that were common in Ford County at the time of European settlement. Some contained an occasional white oak and *Carya ovata* (Mill.) K. Koch (shagbark hickory), but bur oak dominated according to the GLO survey notes. Presently most of these groves have been destroyed, and the few that remain have been highly modified by grazing, cutting, exotic species invasion and fire suppression.

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Mark K. Leach and Thomas J. Givnish

Identifying Highly Restorable Savanna Remnants

Abstract *The restoration of Wisconsin's native oak savannas has become a conservation priority. It is our opinion, however, that thousands of acres of highly restorable oak savannas have been overlooked because of flawed ideas regarding their structure and composition. Commonly, savannas are defined as having a specified "percent canopy" and a prairie-like groundlayer. Percent canopy is a flawed indicator of restorable oak savanna because it does not account for canopy dynamics nor spatial heterogeneity and because, by itself, percent canopy is a poor measure of light penetration to the groundlayer—the home of most plant species. Likewise, the presence of prairie-like groundlayers is not a good indicator of species-rich savanna remnants, especially on more productive soils. We suggest two elements that are both characteristic and diagnostic of highly restorable oak savannas: the presence of historic open-grown oaks and a groundlayer vegetation rich in native plant species in both sunny and shadier locations.*

Land survey records from the 1830s indicate that Wisconsin oak savannas occupied 42% of the land below the Tension Zone (Curtis 1959, Hole 1976). Oak savannas with intact groundlayer vegetation are now considered extremely rare in Wisconsin and the Midwest (Curtis 1959, Nuzzo 1986, Leach and Ross 1995). Oak savanna undoubtedly occurred on a wide range of soil and moisture conditions, on sites with varying fire frequency, and with a concomitant variation in species composition and structure (Curtis 1959, Will-Wolf and Montague 1994, Leach and Givnish in press). John Curtis (1959) in *The Vegetation of Wisconsin* recognized three primary kinds of oak savanna, based on canopy composition and soil conditions. Oak barrens occupied sandy or gravely substrates on upland sites and were dominated by shrubby, multi-stemmed Hill's oak *(Quercus ellipsoidalis)* or black oak *(Q. velutina)*. Oak openings occupied mesic, loamy soils on upland sites and were dominated by large, single-stemmed bur oaks *(Q. macrocarpa),* although white oak (*Q. alba*) and black oak were sometimes common. Lowland oak openings occupied flood plains and glacial lake beds and were dominated by swamp white oak (*Q. bicolor*), although bur oak may have also been common.

In recent years the ecological restoration of oak savanna has become a conservation priority of many public and private land managers (e.g., Kline 1992, Henderson 1995, Leach and Ross 1995, Ross 1997). In Wisconsin, the Fish and Wildlife Service, the Forest Service, the Army, the Department of Natural Resources, the Nature Conservancy, and many local governments are, in many cases, doing a wonderful job protecting and restoring degraded savanna remnants. Ecological restoration is the practice of reconstructing damaged or degraded ecological systems. However, ecologists often lack detailed information on the historic nature of these systems prior to their degradation. Oak savannas, especially on more productive sites, presumably changed rapidly after settlement (Curtis 1959), well before modern ecologists could study them (Packard 1988*a*). The geographic extent of savannas and the paucity of ecological information set the stage for lively disagreements on the nature of savanna vegetation (Leach and Givnish in press). Although conservation agencies for many years have been aware of the recovery potential of degraded savannas, in our view the opportunity for savanna recovery may be much greater than generally recognized.

We contend that many highly restorable oak savannas have not been conserved because their recovery potential has gone unrecognized. Perhaps hundreds of thousands of acres have been overlooked. This probably was due to several factors. The early heritage inventories relied too strongly on Curtis's overly simple models of intact savannas. For many years, little was known about how to "set back" succession in overgrown savannas, which were often valued as forests. Grazed savannas were assumed to be of little conservation value. Thus degraded, but in many cases retrievable, sites were not considered for conservation or were conserved as forests. More recently, we suspect that commonly used search images missed highly recoverable sites, because such search images find some kinds of recoverable savannas but not all.

In this paper we critique commonly used definitions of oak savanna that are based on tree canopy measurements and the presence of prairie-like groundlayers. We suggest conservationists consider alternative search images when inventorying for savanna preserves. We hope this discussion provokes interest in savanna ecology and accelerates the identification and recovery of savanna remnants. Evaluation of both the tree and groundlayer strata is important; however, for convenience we discuss the two separately.

Canopy

Curtis (1959) viewed savanna as transitional between prairie and forest. To classify stands into vegetation types, Curtis made arbitrary (and he clearly called these arbitrary) distinctions among prairie, savanna, and forest. By his definition prairie has less than one mature tree per acre, forest has greater than 50% canopy cover, and savanna lies between. Canopy cover is the portion of sky over an area intercepted by canopy projected downward from above (Nuttle 1997).

Classification of continuously spatially variable vegetation requires setting arbitrary cut-off points (Klijn 1994). In addition to Curtis's definitions, several classification schemes used in the Midwest rely on percent canopy (e.g., United Nations Educational, Scientific and Cultural Organization 1973, White and Madany 1978, Faber-Langendoen 1995). Classification aids communication but can cause problems when arbitrary definitions are used, not to describe, but to prescribe.

In our view, using percent canopy to identify remnant savannas presents at least four serious problems:

1. Percent canopy can be a misleading measure of direct sunlight reaching the groundlayer (Chan et al. 1986, Nuttle 1997), which houses the bulk of plant diversity. Light penetration greatly influences the composition, diversity, and reproduction of plants in the groundlayer (Bray 1955, 1958, 1960; Curtis 1959; Pruka 1994, Hujik 1995, Leach 1996, Leach and Givnish in press). Used alone, percent canopy ignores the influence of canopy height on light penetration (Figure 1). Measuring percent canopy by outlining a tree crown perimeter—its drip line—also neglects the variable amount of light passing through tree crowns. In contrast to the relatively dense shade of oaks grown on productive sites, an oak growing on a drought-prone, nutrient-poor, or otherwise stressful site allows 20% or more of direct sunlight through its sparser foliage (Leach, unpublished data). In contrast to measuring canopy cover, several recent savanna studies (Pruka 1994, Hujik 1995, Leach 1996, Leach and Givnish in press) have used computer analysis of hemispherical photographs, which more appropriately estimate light penetration (Chazdon and Field 1987, Nuttle 1997, Valladares et al. 1997).

2. Savanna trees have long been noted for their spatial heterogeneity, with trees arranged in clusters, groves, peninsulas, or transitions (Gleason 1913, Bray 1955, Curtis 1959, Pruka 1994). Percent canopy is a kind of average spatial description for a stand. Like other averages, percent canopy loses meaning in heterogeneous stands (Figure 2).

3. The percent canopy of a stand describes the present condition, but not past conditions. The suppression of once-common wildfires (Leach and Givnish 1996) allowed many oak savannas to rapidly change into thickets, woodlands, or forests (Ellarson 1949, Curtis 1959, McCune and Cottam 1985, Pruka 1994).

4. Generally, the systems for classification using percent canopy fail to give operational definitions. We assume that those using percent canopy measures are making visual estimates in the field or by inspection of aerial photographs.

For the above reasons, percent canopy is a flawed measure and therefore is of questionable value as a criterion for identifying highly restorable oak savannas. In our experience, a much simpler and much more effective clue to the presence of historic oak savannas is simply the presence of open-grown oak trees. (The inspection of old air photos is also useful.) An oak tree grown in an open, fire-maintained, and therefore high-light environment develops a characteristic form with large horizontal branches (Bray 1955). Such open-grown oaks are still common in pastures, fields, urban parks, and other places where a fresh growth of trees has been kept in check. However, in most such sites (with the occasional exception of those on steep slopes), much of the native groundlayer flora has been lost. Relict, open-grown trees are common in our southern-Wisconsin woodlands and forests where many younger trees have filled in the canopy. Increased shade has caused lower branches to die, leaving dead limbs or trunk scars as evidence.

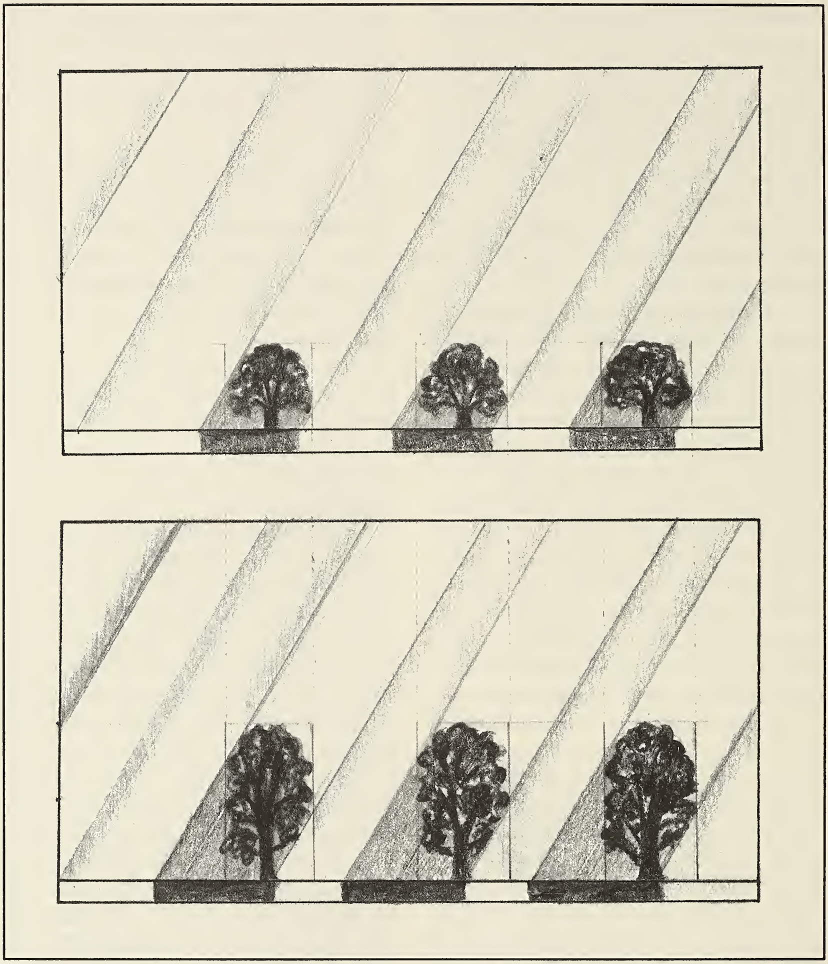

Figure 1. The often-used measure "percent-canopy" does not adequately describe light penetration to savannas groundlayers. By vertical projection, both stands A and B have percent-canopies of 40%. The trees in A are half the height of those in B. At noon on a clear August day the groundlayer in A receives 55% of the potential direct sunlight, while the groundlayer in B receives 40%.

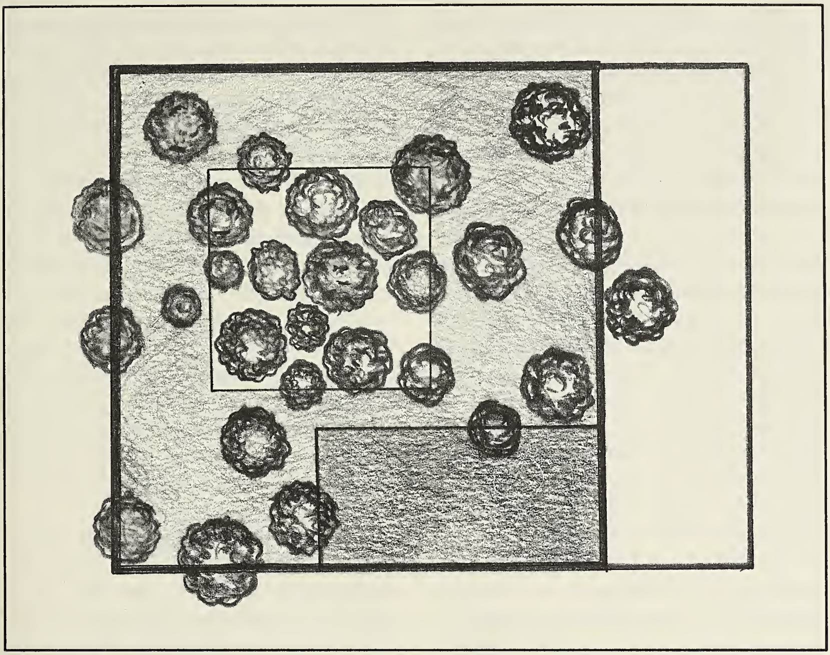

Figure 2. This plan view shows a typical aggregation of savanna trees. The percent-canopy for the area shown is 30%, but varies among sub-areas: A - 36%, B - 72%, C - 5%, and D - 9%. Obviously, the benefits of using percent-canopy as an objective ecological parameter must be weighed against the capriciousness of the areas' boundary.

Groundlayer

While there has been little argument over the canopy composition of historic oak savannas, there has been considerable debate regarding the nature of savanna groundlayers (Packard 1988*a*, 1988*b*, 1993; Anderson 1991; Pruka 1994; Leach 1996; Leach and Givnish in press). Bray and Curtis emphasized the similarity of the savanna flora to that of the prairies. This emphasis is commonly echoed in the description of savanna as "prairie with trees" (e.g., Tester 1995). Specifically, Curtis described the groundlayers of oak barrens as "largely dry-mesic prairie or sand barrens grassland." Similarly he described oak openings as usually a mixture of "bur oak and mesic prairie" or, for the lowland types, a mixture of "swamp white oak and wet-mesic prairies" (p. 326). Curiously, having described the nature of lowland savanna groundlayers, a page later Curtis wrote, "no stands on either wet or wet-mesic sites were found which were not pastured; hence no information is available on these types, except for their tree compositions."

In the 1940s and 50s other researchers working in Curtis's Plant Ecology Laboratory had learned that cattle grazing severely altered the composition of native prairie vegetation, including the loss of certain grasses and forbs (Dix 1955, Neiland and Curtis 1956, Curtis 1959). To avoid sites that were damaged by cattle grazing, Bray (1955, 1958, 1960) selected study sites based on their abundance of warm-season grasses and other prairie plants. Leach and Givnish (in press, Leach 1996) have suggested that Bray's site-selection criteria—his search image—were responsible for his failure to locate savannas "with intact groundlayers" on moister, more productive sites and for Curtis's statement that none could be located to study. Leach and Givnish (in press) used three site-selection criteria that were unbiased regarding the presence of prairie plants: (1) a canopy of open-grown oaks, (2) a groundlayer dominated by native species in both sunny and shaded microsites, and (3) a history of fire during the past 10 years. They found on moist, productive sites, except in the brightest microsites away from trees, that the groundlayer vegetation lacked the warm-season grass and other characteristic prairie plants sought by Bray.

In recent years other conservationists looking closely at the groundlayer have found savanna remnants with a great potential for recovery in lightly grazed oak groves (Martin 1981, Bronny 1989, Rich Henderson, pers. comm.).

Alternate Search Image

We suggest that conservationists seeking highly restorable savannas abandon concern with present canopy conditions and the abundance of prairie species. They should seek evidence of past (and restorable) savanna physiognomy, either by the presence of historic open-grown trees or from old air photographs. They should seek an abundance and diversity of native plants of any kind. There are now several lists of plants associated with savannas to help the field biologist become familiar with this flora (Packard 1988*a*, 1988*b*; Pruka 1994, 1995; Leach 1996; Packard and Ross 1997; Hipp 1998).

By using these simple search images we have located dozens of savanna remnants that are rich in plant species. Several of these sites contained regionally rare species including wild hyacinth *(Camassia scilloides),* late corral-root *(Corallorhiza odontorhiza),* oval ladies'-tresses *(Spiranthes ovalis),* cream gentian *(Gentiana alba),* and little grape-fern *(Botrychium simplex).* In fact, in just 22 sites totaling 42 ha, we found 507 native vascular plant species (Leach and Givnish in press), 27% of the total vascular floral diversity of Wisconsin.

Of course, not all sites are equally rich in species, and the species that are present vary in their rarity and, hence, in their contribution to conservation goals. Many sites dominated by native plants are populated primarily of Pennsylvania sedge *(Carex pensylvanica),* poison ivy *(Toxicodendron radicans),* or other outbreak species. Our assumption is that such sites are not easily restorable without extensive plantings (see Glass 1988, 1989; McCarty 1998), but this is an area requiring new research.

Our recommended search image is admittedly simplistic. However, there is not enough information on the composition of the various kinds of oak savanna to justify a more complex search image at this time. One may be tempted to speculate that high quality savannas should contain mixtures of plants from the prairie and the forest along with savanna specialists. However, the composition of any savanna is most likely dependent on its landscape context: greater diversity of prairie species in savannas surrounded by prairies, greater diversity of forest species in savannas surrounded by forests. The number of true savanna specialists is probably low in any case. As conservationists become more experienced in locating species-rich savanna remnants and more information becomes available on their constituent flora, we may develop search images using indicator species. Pruka (1995) provides a tentative list of indicators for Wisconsin.

Conclusion

The ability to locate species-rich savanna remnants for conservation can be considered a test of our ecological ideas. Many species-rich, restorable savanna remnants have been overlooked because of the wide acceptance of two flawed ideas: (1) that savannas fit neatly into a range of canopy percentages and (2) that savanna vegetation is essentially prairie with trees. Re-setting our search images to seek historic open-grown trees with native-plant groundlayers (regardless of the abundance of prairie plants) is helping identify important stands for conservation. We hope new search images will spark greater interest in locating additional sites before their restoration become too costly if not impossible.

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Black Soil Prairie Groves of the Headwaters Region of East-Central Illinois

Abstract *Prairie groves associated with morainal ridges were relatively common plant communities within the Grand Prairie Division of Illinois. The composition and structure of the overstory of four groves were examined during this study. All were on morainal ridges with depressions to the north and west that originally contained wetland communities. The few remaining groves are dominated by open-grown* Quercus macrocarpa *Michx. (bur oak), sometimes along with* Carya ovata *(Mill.) K. Koch (shagbark hickory), and rarely a few other species. Heavily grazed until the middle of the twentieth century, these groves lack the herbaceous and woody understory of presettlement times.*

At the time of European settlement the most prominent landscape feature of Illinois was extensive tallgrass prairie that covered 61% of the state (Iverson et al. 1989). Within this grassland of the Grand Prairie Division were scattered prairie groves along with extensive tracts of timber along rivers and streams (Schwegman 1973). The species composition and structure of these forested tracts was determined by topography, climate, soils, and extensive fires that regularly burned across the region (Gleason 1912, 1913; Ebinger and McClain 1991; McClain and Elzinga 1994).

During pioneer times, two common types of prairie groves were found in the Grand Prairie Division of Illinois: (1) streamside groves associated with water courses and (2) isolated groves on morainal ridges that were somewhat protected from fires by sloughs. The streamside groves were usually extremely large, some extending over an area of five or more square miles (Boggess and Bailey 1964, Boggess and Geis 1966). Gleason (1913) suggested that these groves had been cut off from larger forest areas by attrition from repeated fires. In contrast, based on Government Land Office (GLO) survey notes, the prairie groves on morainal ridges were much smaller and rarely exceeded one square mile in size.

Large remnants of these extensive streamside groves, modified by disturbance and fire suppression, still exist. A few have been studied, including the Funks Grove Natural Area along Timber Creek, McLean County (Boggess and Geis 1966, Cox et al. 1972), Trelease Woods (Pelz and Rolfe 1977), and Brownfield Woods (Boggess and Bailey 1964), the last two being remnants of the "Big Grove" along the Salt Fork River in Champaign County. In these forests 20 or more tree species entered the canopy, the majority being thin-barked, fire-sensitive species such as *Acer saccharum* Marsh. (sugar maple), *Ulmus* spp. (slippery and American elms), *Tilia americana* L. (linden), and *Celtis occidentalis* L. (hackberry). Oaks were important components, *Quercus alba* L. (white oak) being common, *Q. macrocarpa* Michx. (bur oak), and *Q. velutina* Lam. (black oak) usually present as scattered, large-diameter trees. The presence of the thin-barked, fire-sensitive species suggests that the interiors of these large groves only occasionally burned. Based on GLO survey notes, presettlement forest vegetation along the Mackinaw River valley in central Illinois was highly diverse (16 species) with many thin-barked species (Thomas and Anderson 1990). White, bur, and black oaks were important on the terraces where fires were more intense.

In contrast, the isolated prairie groves on morainal ridges were small, closely resembling the "bur oak openings" of Wisconsin, Minnesota, and Michigan (Stout 1946, Curtis 1959). Sometimes described as natural parks (Curtis 1959), these groves were composed almost exclusively of bur oaks that were "all broad-topped and so spaced that seldom are the branches of two trees interlocked" (Stout 1946). These communities were probably subjected to occasional, intense fires, as the dominant bur oaks were mostly open-grown. Thin-barked, fire-sensitive trees seldom occurred here.

In Illinois the vegetation of the prairie groves on morainal ridges has rarely been studied. The few groves that remain have been extensively degraded by grazing, cutting, exotic species invasion, and fire suppression. This study was undertaken to determine the present composition and structure of the overstory of some of these groves and to determine their similarity to other forests of the Grand Prairie Division of Illinois.

Description of the Study Areas

The groves studied are located within what is referred to as the "headwaters region" of Ford County, Illinois (Anonymous 1871). Five rivers have their origins here: the Mackinaw, Vermilion, Sangamon, and Middle Fork Rivers, and Spring Creek, a tributary of the Iroquois River. None of the groves were located next to a stream, all being on morainal ridges with depressions to the north or west that originally contained sloughs and sedge meadows. Presently these depressions are cultivated fields, but soil cores show that two to six feet of top soil covers the Houghton muck that was present in the wetlands at the time of settlement. The soils of these groves are silt loams that developed in shallow loess on calcareous glacial tills of Wisconsin age (Fehrenbacher 1990). Surrounding are dark clay loams to silty clays that developed under prairie vegetation. Except for one section corner, where two bur oaks were listed as witness trees, the GLO survey notes give little indication of species composition or structure of these groves.

Beeset Bur Oak Grove. About 2 km northeast of Roberts, Illinois (S 11 T25N R9E), this grove is located on a long morainal ridge with an extensive lowland to the west and northwest. About 7 ha in size, sections of the grove had been recently disturbed by cutting, and a house with out-buildings was located in the eastern quarter. A part of the grove, 4.61 ha in size, was relatively undisturbed and was surveyed during this study. According to the headwaters map (Anonymous 1871), the grove covered about one-quarter of a section.

Sibley Burr Oak Grove Nature Preserve. Located 1 km southeast of Sibley, Illinois (S 35 & 36 T25N R7E), this grove is on a broad morainal ridge with wetlands to the north and west. It was described in the GLO survey notes as an oak-hickory forest with an undergrowth of hazel approximately one-third of a section in size. The grove is divided into two parts separated by a slough: an eastern section of 13.75 ha, and a western section of 1.62 ha.

Wildcat Bur Oak Grove. Located about 4 km southwest of Sibley, Illinois (S 8 & 17 T24N R7E), the grove is on a narrow morainal ridge with wetland depressions to the north and west. Presently the grove is 4.78 ha in size with an east/west county road traversing the southern quarter. A farm house is located within the southeastern part of the grove, the yard dominated by large bur oaks. According to the headwaters map (Anonymous 1871) the grove covered nearly one-fifth of a section.

Materials and Methods

All of the remaining isolated groves in Ford County were visited, and those that showed the least evidence of recent cutting or other major disturbance were selected for study. The size of each grove was determined by measuring the area using aerial photographs to determine the number of hectares present.

During the summer of 1997 the number, size, and species of all living canopy and subcanopy trees 25 cm dbh and above were recorded at each grove. From these data the density (stems/ha) in broad diameter classes, basal area (m^2/ha), relative density, relative dominance, importance value (IV), and average diameter (cm), were calculated for each species. The IV determination is the sum of the relative density and relative dominance for each species with a total possible of 200 (McIntosh 1957). Nomenclature follows Mohlenbrock (1986).

Results

In the groves listed below, bur oak was, by far, the dominant species, accounting for most of the density and basal area (Table 1). Most of the trees had broad, open-grown crowns, characterized by 2–7 major crown branches rather than a single trunk. Most also had low branches or branch scars within 1–4 m of the ground.

Beeset Bur Oak Grove. The overstory of this grove averaged 75.4 stems/ha with a basal area of 18.55 m^2/ha (Table 1). Bur oak and shagbark hickory were the important components with IV's of 162 and 32 respectively. Bur oak averaged 59.4 stems/ha, a basal area of 15.54 m^2/ha, and averaged 56.7 cm dbh. Of the 274 individuals of this species in the grove, all but 12 had diameters less than 80 cm dbh, suggesting past cutting. Coppice bur oaks averaged 2.4 trees/ha. Individuals of shagbark hickory were scattered throughout the grove, averaged 14.5 stems/ha, a basal area of 2.45 m^2/ha, and no coppice individuals.

Table 1. Diameter classes, relative values, importance values and average diameters of the woody overstory species in the bur oak groves of Ford County, Illinois.

Species	Diameter Classes (cm) 25–40	40–59	60–79	80–99	100–119	120+	Total #/ha	Basal Area m^2/ha	Relative Density	Relative Dom.	IV	Average Diameter (cm)
Beeset Grove — 4.61 ha (11.4 acres)												
Bur oak	5.0	33.6	18.2	2.6	--	--	59.4	15.54	78.7	83.8	162.5	56.7
Shagbark	4.3	9.3	0.7	0.2	--	--	14.5	2.45	19.3	13.2	32.5	45.2
Hackberry	0.9	--	0.2	--	--	0.2	1.3	0.48	1.7	2.6	4.3	55.9
White oak	--	--	0.2	--	--	--	0.2	0.08	0.3	0.4	0.7	66.7
Totals	10.2	42.9	19.3	2.8	--	0.2	75.4	18.55	100.0	100.0	200.0	
Sibley Grove (East Section) — 13.75 ha (34 acres)												
Bur oak	2.4	13.6	11.7	7.0	2.8	1.3	38.8	16.33	98.5	98.5	197.0	69.9
Black walnut	--	0.2	0.1	0.3	--	--	0.6	0.24	1.3	1.4	2.7	75.3
White oak	--	0.1	--	--	--	--	0.1	0.02	0.2	0.1	0.3	51.3
Totals	2.4	13.9	11.8	7.3	2.8	1.3	39.5	16.59	100.0	100.0	200.0	
Sibley Grove (West Section) — 1.62 ha (4 acres)												
Bur oak	5.6	30.9	25.3	8.0	1.9	1.2	72.9	24.37	98.3	98.5	196.8	62.9
Black walnut	--	0.6	0.6	--	--	--	1.2	0.38	1.7	1.5	3.2	62.3
Totals	5.6	31.5	25.9	8.0	1.9	1.2	74.1	24.75	100.0	100.0	200.0	
Wildcat Grove — 4.78 ha (11.8 acres)												
Bur oak	5.7	17.2	19.5	8.6	2.3	1.3	54.6	20.48	98.5	97.4	195.9	65.7
Hackberry	--	--	--	0.2	0.4	--	0.6	0.50	1.1	2.4	3.5	100.8
Black cherry	--	0.2	--	--	--	--	0.2	0.04	0.4	0.2	0.6	46.2
Totals	5.7	17.4	19.5	8.8	2.7	1.3	55.4	21.02	100.0	100.0	200.0	

Sibley Burr Oak Grove Nature Preserve. In the large eastern grove the woody overstory averaged 39.5 stems/ha with a basal area of 16.59 m^2/ha (Table 1). Of the 540 canopy and subcanopy trees recorded, all but eight were bur oaks. The average diameter for bur oak was 69.9 cm dbh, and 170 individuals had diameters greater than 80 cm. Of these, 61 had diameters in excess of 100 cm dbh. Coppice individuals were extremely rare. In the small western grove, overstory density averaged 74.1 stems/ha with a basal area of 24.75 m^2/ha (Table 1). Bur oak dominated, accounting for nearly all of the IV; of the 120 individuals encountered, 118 were bur oaks. Bur oaks averaged 63 cm dbh, with over 71 stems/ha being less than 80 cm dbh. No coppice stems were encountered.

Wildcat Bur Oak Grove. Overstory density averaged 55.4 stems/ha with a basal area of 21.02 m^2/ha (Table 1). Bur oak accounted for nearly all of the IV. Of the 260 individuals of bur oak encountered, 202 were less than 80 cm dbh, and only 17 exceeded 100 cm dbh. Coppice bur oaks averaged 5.6 trees/ha, with an average of 2.19 stems/tree.

Discussion

All of the groves studied had relatively high tree densities, ranging from 39.5 stems/ha in the eastern section of Sibley Grove to 75.4 stems/ha in Beeset Grove. Except for scattered openings where trees had recently died, these groves were closed forests where individual tree crowns usually overlapped. These tree densities are low compared to streamside groves of central Illinois (Boggess and Bailey 1964, Boggess and Geis 1966, Cox et al. 1973, Pelz and Rolfe 1977) where densities averaged 300 stems/ha. Before European settlement these groves on morainal ridges were probably more open. As these groves had wetland communities to the north and west (sloughs and sedge meadows) some prairie fires did not reach the groves, allowing for high litter loads. Fires that crossed these wetlands during drought years resulted in the death of many small diameter bur oaks as well as any thin-barked trees that were present.

Most of Ford County was described in the GLO survey notes of 1823 as "2nd rate prairie, land gently rolling." The occasional grove was usually described as an oak-hickory forest. Other than the mention of an "undergrowth of hazel," no information was given on the understory of these groves. Presently the understory contains many weedy and exotic woody species, the most common being *Prunus serotina* Ehrh. (black cherry), *Crataegus mollis* (Torrey & Gray) Scheele (red haw), hackberry and *Lonicera maackii* (Rupr.) Maxim. (Amur honeysuckle). Sometimes bur oak and hickory reproduction occurs, particularly in canopy openings and at the grove margins. The herbaceous layer is dominated by Eurasian, cool-season grasses along with numerous introduced and weedy annuals and perennials. Occasionally a few native woodland grasses and sedges are encountered, and rarely a few perennial prairie species.

Many of the trees in these groves were established long before European man settled the area. The settlement of Ford County did not begin until the railroads came in the 1860s. The numerous sloughs and sedge meadows of the region presented major drainage and transportation problems, and human diseases helped to make this area very unattractive to settlers. A few dead bur oaks in the groves were cut, and individuals between 85 and 145 cm dbh had from 225 to 330 growth rings.

Conclusions

These bur oak-dominated groves are open, averaging between 39 and 75 trees/ha. Most of the bur oaks have branches or branch scars within 4 m of the ground. In the past fire was undoubtedly responsible for maintaining the open conditions of these groves, as well as the very low species diversity of the canopy. This community type is distinct from the streamside forests and groves of the Grand Prairie Natural Division of Illinois. In the streamside forests and groves, tree species diversity is high, tree densities usually exceed 300 stems/ha, and many thin-bark, fire-sensitive species are important forest components.

Only a few of the groves associated with morainal ridges remain, and these have been highly modified by cutting, fire suppression, and exotic species invasion. Due to the ease of clearing these sites, as well as the very productive soil, 14 groves in Ford County have been cleared since the early 1960s (Robert Reber, personal communication).

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Jon Mendelson

Restoration from the Perspective of Recent Forest History

The woodlands of northeastern Illinois, particularly those associated with the Valparaiso, Tinley, and Lake Border Moraines that encircle Chicago and extend northward through Kenosha and Racine counties in Wisconsin, are extensive, constituting substantial remnants of the original forests of the area.[1] Oak dominated, they are similar in species composition from north to south. The soils that developed under them, principally the alfisols Morley and Blount silt loam, are also widespread, extending from Indiana well into southern Wisconsin (Hole 1976, Mapes 1979). These woodlands typically occupy north- and east-facing morainic slopes, and, as has often been noted, they are best developed on the east sides of streams (Gleason 1909, Woodard 1925, Bowles et al. 1994). Perhaps the large amount of forest in the area is related to the north-south orientation of many of its rivers, including the DuPage, the DesPlaines and the North Branch of the Chicago.

As Cowles (1901) pointed out almost a century ago, the landscapes occupied by these woodlands are among the most dynamic in the region. It is here that post-glacial stream dissection and the consequent maturation of drainage basins is most advanced. This maturation is expressed in the ravine topography characteristic of these woodlands, the "broken" lands of the Public Land Survey notes, and is largely a function of the interplay of forest and stream in these landscapes. The forest, once established, provides a land surface more conducive to stream development than does prairie sod. Resulting channel

[1] I am using the terms "woodland" and "forest" interchangeably, not as distinct community types separated on the basis of density, canopy closure, basal area, etc. There is some question as to the value of making this distinction for northeastern Illinois woodlands.

lengthening and valley widening provide not only avenues for forest advance, but an increasingly diverse set of interior forest habitats, ranging from floodplain and terrace, to mesic ravine slopes, to dry uplands and wet depressions as yet unaffected by stream dissection.

It is this assemblage of woodlands, all recognizably similar in physiognomy and composition but each subtly different from the others, that has become the principal target of restoration efforts during the last decade.

Forest History

Because forested landscapes, alone among terrestrial communities, have a readable history, we have the unique opportunity to place ecosystem processes in an historical context. This history can be read not only in Public Land Survey descriptions, but in tree rings, in fire scars, in changing species composition between canopy and understory, in size and age distributions. The meticulous reconstruction of Henry and Swann (1974) is an example of what can be done in this regard. Other studies in forest history are reviewed in Peterken (1996). Beyond the inherent value of such studies, it is critical for those of us interested in the morainic forests of northeastern Illinois to devote more time to their history, to understanding the forces that shaped them, and to the expression of these forces in the present-day forest. I say this because I believe the existing assumptions about forest history, the assumptions that are presently guiding restoration activities in these woodlands, are simplified at best, badly flawed at worst.

Pre-settlement History

First, I think we need to reevaluate some of our assumptions about historic disturbance patterns in northeastern Illinois. To begin with, we need to analyze critically the idea that these woodlands have some evolutionary relationship to fire, that they have "evolved [with fire] over the eons" (Packard 1993:8). As Hunter (1996) has pointed out, the time period since deglaciation, ~12,000 years, is not long enough for the evolution of species, no less the community-level evolutionary response to fire that has been suggested. Griffin (1994) makes the same point in reference to the origin and development of savannas about which similar evolutionary claims have been made. Moreover, the data that supports the frequent recurrence of fire is entirely anecdotal. We have no information on fire scars from the few pre-settlement trees still present in these woods. Fire or its effects are rarely mentioned in the Public Land Surveys, even though most were conducted in pre-settlement times in this region. Perhaps we need to approach the question of disturbance regimes from the perspective of the pre-settlement forest itself. For example, unpublished data on the size distribution of witness and line trees, 79 in all, from the 1834 Survey of Thorn Creek Woods in Will County, one of these morainic woodlands, includes individuals ranging in size from 7" (17.5 cm) to 24" (60 cm) in dbh, with all intermediate sizes represented. This distribution suggests an all-aged forest existing on the site prior to settlement. Anderson and Anderson (1975) found the same pattern in the forests of Williamson County in far southern Illinois. The implication of an all-aged structure is continuous recruitment, and this, in turn, suggests low levels of disturbance during what appears to be a relatively long period of forest establishment. Clearly, these results are preliminary, but I think they are sufficiently at variance with established conceptions of pre-settlement fire-frequency, conceptions that are driving present day restorations in these same woodlands, that the whole subject might profitably be revisited.

Although we have much to learn about pre-settlement conditions, I believe we should focus most of our attention on post-settlement forest history, agricultural history, patterns of land use in the forest in the 160–170 years since settlement. These topics are more mundane perhaps than the romance of a pre-settlement Eden, but they are, at the same time, more germane to the organization of the forest we now see. The post-settlement agricultural period in northeastern Illinois has in recent years come to be characterized as nothing more than a misguided era of fire suppression (Packard 1993). By doing so, we have ignored two other factors—logging and grazing—whose impact on these forests was of equal or greater significance during the same period and whose long-enduring effects explain much about the structure of today's woodlands.

Logging

The trees of the pre-settlement forest, with few exceptions, are gone from northeastern Illinois woodlands. Most have been logged off, probably within the first eighty years or so of settlement. The principal legacy of logging, presumably in concert with early fire suppression, has been the emergence of the even-aged canopy we see in these woodlands today, a canopy composed almost exclusively of post-settlement trees or those of immediately pre-settlement origin. Cowles' (1901) photographs of typical morainic woodlands show two of these even-aged, second-growth stands as they appeared almost 100 years ago (Figures 1 and 2). At the present time, this canopy, whose success was made possible by the removal of the original forest, is now in full maturity region wide, approaching old-growth status in age.

Early plats show that many of the larger woodlands—Thorn Creek, Plum Creek and Messenger Woods in Will County, for example—were subdivided into numerous small (10–25 acre) woodlots owned by prairie farmers (Figure 3). A similar pattern was found in La Salle County, Illinois (Fuller 1923). Differences in the degree to which these woodlots were harvested created a mosaic of disturbance in these forests. Adjacent woodlots, for example, may have had wholly different histories of exploitation. The imprint of these differences are still detectable in present-day forests.

The implications of the post-settlement origin of our woodlands goes beyond simply the replacement of one generation of trees by another. There has most certainly been an increase in tree density, for example, even in the larger size classes, and with that, a change in tree form, individuals developing a straighter, more forest-grown shape. Restoring the pre-settlement woodland is impossible: the pre-settlement forest is gone. It is not there to be restored. The real management issue is whether it is desireable, or even possible, to recreate a pre-settlement facsimile from the existing forest, given the changes that have occurred.

Grazing

The effects of grazing on these woodlands have been equally profound and equally overlooked. Dairy farming in northeastern Illinois was restricted to morainic landscapes, the very same landscapes that supported extensive tracts of forest (Duddy 1929). I think we have underestimated the ubiquity of grazing in these woodlands. In 1925, for example, just prior to the period of rapid

Figure 1. An even-aged post-settlement stand in 1901. The trees appear to be about 40 to 50 years old. Only the stump in the foreground and possibly the larger tree in the upper left remain from pre-settlement times. Beverly Hills is in southwestern Cook County. Photo courtesy of the University of Chicago Press.

decline in regional agriculture, 92% of 23,000 acres of woodland in Cook County had been or was being grazed; similar percentages were recorded for DuPage, Lake, and Will Counties (Telford 1926, Duddy 1929). A survey of 430 northern Illinois farmers taken during this same period revealed that over 90% grazed their woods (Telford 1926).

The effects of livestock grazing in woodlands are varied, depending on the intensity and duration of the practice. These include soil compaction, which in extreme conditions results in stag-headed trees, and the replacement of the woodland herbaceous layer by bluegrass sod, Canada thistle, and other alien invaders. The stages of forest degradation under increasingly severe grazing pressure were outlined by DenUyl and Day (1939). The subject was recently revisited by Dennis (1997). One result emerges above all others: protracted grazing results in the elimination of the existing woody understory (Figures 4 and 5) and in the cessation of woody plant recruitment (Marks 1942, Dambach 1944, DenUyl 1962). Fuller and Strasburgh (1919:271) concluded that, as a result of grazing "... not over 5% of the oak and bottom forests show reproduction in progress" in La Salle County, Illinois. In the present-day forests of northeastern Illinois the most striking imprint of past grazing is the gap in the size distribution of virtually every species of tree in these woodlands (Men-

Figure 2. Another even-aged stand in 1901. Note the high stem density and the straight, slender forest-grown form of the trees. The tree on the left with the crooked trunk may be the only pre-settlement survivor. Photo courtesy of the University of Chicago Press.

delson 1994). The gap represents the period when, as a result of grazing, tree recruitment essentially ceased.

Recovery of the forest presumably also depends on the previous duration and intensity of utilization. Complete recovery may be slow. Curtis (1959:154-5), who suggests that soil compaction might be the most damaging and the most permanent effect, mentions a lightly grazed red oak stand protected from cattle in 1932 whose recovery was still incomplete 25 years later. It is in this recovery phase that the woodlands of northeastern Illinois are today, and the degree to which they have recovered is inversely proportional to the severity of past disturbance.

Recovery

The most direct response to the cessation of grazing has been the explosive growth of the understory of these woods, beginning in the 1920s with the regional decline in agriculture. The understory that has emerged is clearly delimited from the older, canopy generation by a spatial gap: middle-sized trees of middle-age are largely absent from these woods. The regeneration of the forest which this understory represents may, at first glance, appear chaotic. We have been made all too aware of its less desirable aspects, particularly the inclusion of non-native, sometimes aggressive elements like buckthorn, multiflora rose, honeysuckle,

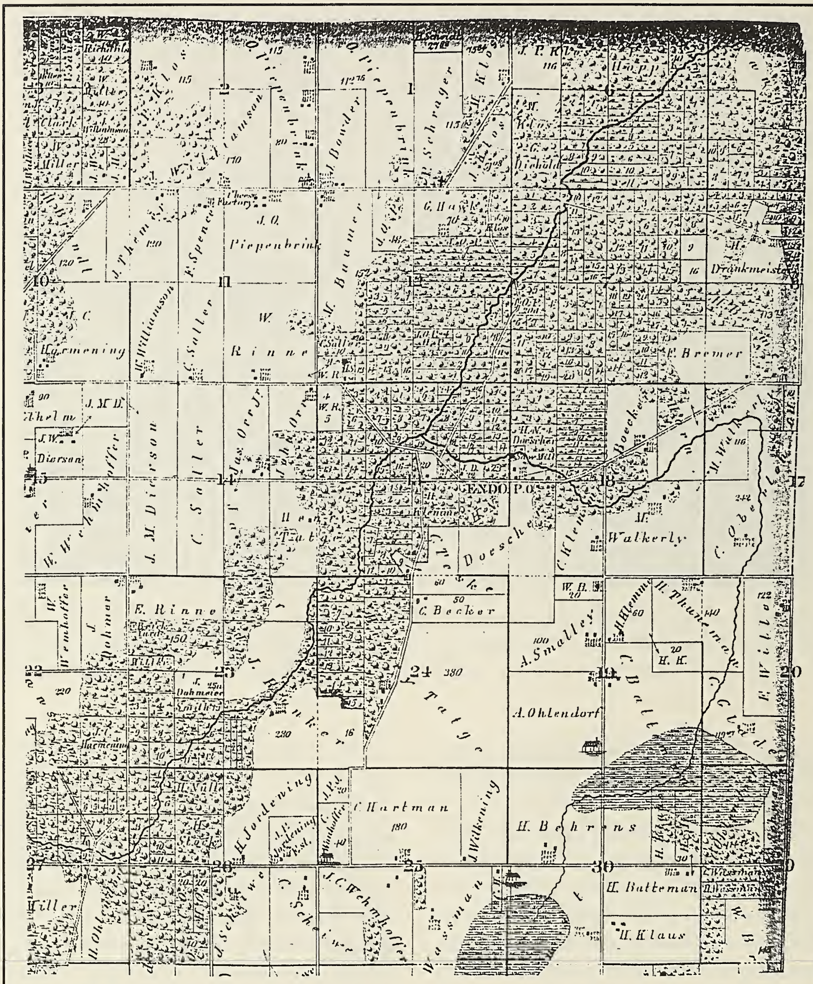

Figure 3. 1873 plat of the northeastern portion of Crete Township, Will County, Illinois, showing the forest along Plum Creek subdivided into many small woodlots. Note the sawmill in the northwest quarter of section 18. The map is from the Atlas of Will county published in 1873 by Thompson Bros. and Burr.

Figure 4. This photo is from "A Manual of Woodlot Management" by C. J. Telford, published in 1926. The woodlot is located in northern Illinois. Photo courtesy of the Illinois Natural History Survey.

Figure 5. Grazing continued in some forest preserves even after acquisition. This photo is from 1921. Deer Grove Preserve is located in northwestern Cook County. Note the browse line in the background and the virtual absense of understory. The plants in the right foreground appear to be Canada thistle. Photo courtesy of the Cook County Forest Preserve District.

and others in the emerging community. The distribution of most of these alien species, however, seems closely associated with the degree of past disturbance: to a large extent, they have invaded the most disturbed sites, those which are also slowest to recover. Moreover, most of the aliens are shrubs or small trees. None have the capacity to become part of the upper canopy. Species having canopy-forming potential in these woodlands are all native, and all are participating to various degrees in forest regeneration. The early stages in the recovery from grazing are, first, the spread of existing thorny or unpalatable species, of which hawthorn is usually most prominent, which is followed by the arrival of light-seeded and bird-disseminated tree species: ash, slippery elm, sugar maple, basswood, and black cherry, among others. Oaks generally appear later in the process (Den Uyl and Day 1939, DenUyl 1962). This sequence seems to describe very well the pattern of species appearance in northeastern Illinois woodlands, where white ash, slippery elm, and black cherry are frequently found beneath a much older, oak-dominated canopy, and where once vigorous stands of hawthorn are already in decline. The spread of sugar maple from ravine enclaves onto the more mesic of upland sites has been widely commented upon. Maples are still largely absent from dry uplands, which are equally open to invasion, suggesting that edaphic factors, particularly available soil moisture, may be limiting. A recent reexamination of Illinois Natural Areas Inventory sites originally sampled in 1976 indicates an increase in sugar maple in the smallest size class on oak-dominated sites, but virtually no growth into larger size classes during the last 20 years (Bowles et al. 1998*a*).

Why oaks are slow to reestablish in previously grazed settings is not clear. It would seem to be related in part to soil compaction, the most persistent legacy of grazing, and its effects on germination and seedling establishment. Certainly the extreme sensitivity of mature oaks in northeastern Illinois to soil compaction, as witnessed by their high mortality rates around construction sites, has been ajmply demonstrated (Ware and Howe 1974).

There seems to be fairly general agreement that oak populations can be self-sustaining on dry sites (Clark et al. 1996, Fralish, 1997). This seems to hold true for northeastern Illinois woodlands as well, especially where grazing appears to have been light. For example, at the Illinois Natural Areas Inventory (INAI) site in Thorn Creek Woods (Bowles et al. 1998*b*), an area that was apparently lightly grazed and has no history of fire, oak seedlings were present in numbers estimated between 2,500 and 6,500/ha.

In places we see the beginnings of an all-aged structure in these woodlands, with the establishment of a variety of canopy species, including oaks, beginning perhaps 60–70 years ago and continuing today.

These are only a few of the many changes that have come about since the cessation of grazing, changes that are still unfolding, and about which we still have much to learn. To dismiss these complex developments as nothing more than forest deterioration due to fire suppression is a misreading of the past.

Restoration

Such a misreading would be of only academic interest were it not the main justification for restoration efforts in these woodlands, efforts aimed almost exclusively at altering or removing the understory, at reversing the degradation that this outpouring of vegetational energy is supposed to represent. At first, reintroducing fire, the process under which these woodlands allegedly evolved, was the principal method employed. Now, woody species in the understory are routinely cut or girdled first, and then treated with herbicide, usually prior to the application of fire. The latest device to come into use is the Seppi mower, a variant of the brush hog, which leaves a litter of wood chips, and almost certainly compacts the soil of the forest floor, mimicking, in an ironic way, the hooves of cattle. Lack of a sufficient fuel load, and hence the inability of these woodlands to carry a fire hot enough to do its job, is usually offered as the explanation for employing these increasingly severe methods of control. Species that are removed include not only aliens like buckthorn and honeysuckle, but many natives as well: ash, elm, black cherry, sugar maple, and basswood. Most of these are early colonizers after the cessation of grazing.

Reintroducing chronic disturbance into these woodlands has had some unpleasant results. One is the reappearance of species that thrived under heavy grazing. White snakeroot, which can form virtual monocultures in restored woodlands, is an example (Marks 1942). More alarming is the recurrence in restored woods of some of the most pernicious agricultural weeds: Canada thistle, burdock, and mullein among others. This is particularly evident in parts of Swallow Cliff Forest Preserve, Cook County's currently most ambitious restoration. These species are found only in the most degraded of woodland pastures and are eventually eliminated as the forest recovers. They are never part of a healthy woodland flora. Thus in many cases, we appear to be replacing what have been deemed aggressive woody species, including many natives, with equally aggressive herbaceous ones. This is not surprising: with disturbance-based management come disturbance-adapted species, and many of these are aggressive competitors.

It has been suggested that garlic mustard, the latest scourge of our woodlands, also may be favored by disturbance-based management (Anderson et al 1996). Frequency of garlic mustard was significantly higher in burned INAI sites than in those that had not experienced fire management (Bowles et al. 1998*a*). Fire may open seed beds, thus facilitating the spread of this species.

More dangerous than the spread of undesirable species, a process which presumably would be reversed with the cessation of disturbance, is the permanent effect restoration is having on forest structure. Under current management practices, we continue to widen the age gap between an increasingly elderly canopy and what will forever be an immature understory. We are, in other words, prolonging the even-aged condition which itself is an artifact of post-settlement logging and grazing. This takes on particular significance when we consider that some canopy species, notably red and black oak, may be approaching, at 150–180 years of age, the end of their life span. If oak reproduction is not enhanced by current management—there is yet little evidence that it has been—and we continue to remove almost every other native tree species, we may be having impacts on these woodlands more damaging and more permanent than those of the preceding agricultural period. These unexpected effects are the result of our one-dimensional interpretation of recent forest history, and our failure to take into account the sequence of changes that follow the removal of livestock from the land.

I think it is fair to ask, therefore, whether it is wise to continue to impose disturbance-based management on woodlands that have so recently emerged from a long post-settlement period of disturbance. After all, in their entire post-glacial history, these woodlands had never before been cut. Nor had they experienced as intense a period of grazing as they have since settlement. Given this history, might it not be equally appropriate to let biotic interactions, particularly interspecific competition, in this emerging forest determine ultimate forest structure? If so, then management should emphasize stability and reduce chronic abiotic disturbance. The successional trajectory under these conditions may never return us to pre-settlement structure or composition. But then, neither will current management practices: these forests have gone too far down a different road. What we will have, if we manage for stability, are all-aged woodlands, woodlands with greater species diversity in the canopy than we see at present, woodlands that have developed under the natural disturbance regime of this time and place.

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Scott E. Nielsen and Alan Haney

Gradient Responses for Understory Species in a Bracken Grassland and Northern Dry Forest Ecosystem of Northeast Wisconsin

Abstract *Spread Eagle Barrens, located in Northeastern Wisconsin, occupies an area of pitted outwash created during the late Wisconsin glaciation. This irregular topography forms a heterogeneous landscape influencing both site characteristics and associated plant communities. Today the dominant plant communities, which often occur in a mosaic pattern, consist of both bracken-grasslands and northern dry forests. It is in this landscape that we investigated the distribution and position of 35 groundlayer species along six environmental gradients and one competitive gradient. These include slope position, site severity index, canopy, soil nutrient index, organic matter, pH, and bracken fern frond densities. The presence or absence of each species, along with environmental data, were recorded in random 1 m^2 quadrats placed throughout the Sand Lake Region. Probability responses of individual species along measured gradients were then determined through logistic regression. Response shapes of species across gradients were often non-linear, with both quadratic and cubic functions being common. Results indicate that topoedaphic factors, canopy and bracken fern all influence species distributions. Overall, however, canopy was the single most important gradient examined. Bracken fern frond densities also showed strong significance for many species indicating the important role it plays on the landscape. Additionally, as predicted by competition theory, bracken fern was also found in the center of environmental gradients where the strongest competitors are thought to dominate.*

Savannas are one of the most extensive and socioeconomically important ecosystems on the planet, covering over 18 million km^2 or 14% of the earth's surface (Botkin et al. 1984, Perry 1994). In Wisconsin one type of savanna, called pine barrens, once occupied a large portion of the state covering over 947,000 ha at the time of European settlement (Curtis 1959). Today, however, many of our native Midwestern savanna communities are rare (Nuzzo 1986) due to fire suppression and associated woody encroachment (Abrams 1992). The situation for pine barrens in Wisconsin is no different. Only about 20,000 ha currently remain of both oak and pine barrens (Mossman et al. 1991).

Two distinct forms of pine barrens can be recognized based on the groundlayer composition, perhaps reflecting soils, topography, and location to tension zone (Vogl 1970). The first type, prairie-like barrens, tend to occur in coarse sands, gentle topography, and are geographically close to prairies. The second type, non-prairie barrens, tend to occur in loamy sands and sandy loams, have more topographic variability, and are relatively isolated from prairies or the tension zone. The latter community, which rarely has received attention, also includes that which has been referred to as depauperate bracken-grasslands (Vogl 1964*a*). These bracken-grasslands were initially assumed to be secondary communities in Wisconsin resulting from logging and fire. However, based on both ecological studies of northern Wisconsin (Curtis 1959, Vogl 1964*a*) and European records, it appears that the bracken-grassland community was indeed part of the state prior to settlement, although in relatively small coverage. It since has expanded due to anthropogenic causes.

Today, these bracken-grassland communities are often integrated into a mosaic of other communities in northern Wisconsin, particularly northern dry forests. In some instances, many can even attain the appearance of an aspen parkland, with the dominant woody species being aspen (*Populus tremuloides* and *P. grandidentata*). Once bracken-grasslands are established, they are fairly resilient and do not appear to require fire for their maintenance (Vogl 1964*a*), unlike other savanna communities of the Midwest (Bray 1955; Curtis 1959; Vogl 1964*b*, 1970; Kline and Cottam 1979; Grimm 1984; Haney and Apfelbaum 1990; Leitner et al. 1991; Abrams 1992). Possible mechanisms responsible for this maintenance are competition and microclimate.

Competition between tree seedlings and bracken fern may inhibit or limit succession (Curtis 1959, Vogl 1964*a*). Bracken fern (*Pteridium aquilinum* L. Kuhn), which is the most widely distributed plant in the world (Page 1982), has an excellent ability to compete for moisture, nutrients, and light. In addition to direct competition for resources, bracken fern can also inhibit plant establishment and growth through allelopathy (Ferguson and Boyd 1988). Bracken fern rhizomes also quickly invade or re-establish following disturbance (Conway 1952). Many of the bracken-dominated systems of the world today are associated with disturbances such as fire, timber harvesting, or grazing. In Finland, Oinonen (1967) was able to positively correlate clone sizes of bracken fern to time of last fire, with ages of clones going back to the years of 1300 (old fortress at Sulkava) and 1318 (Turku raided) and clone sizes exceeding 200 m in diameter.

The second factor potentially influencing the stability of bracken-grasslands, at least in Wisconsin, is the microclimate (Curtis 1959, Vogl 1964*a*). In many areas where bracken-grasslands dominate, the landscape (pitted outwash) promotes drastic changes in temperature, including the frequent frost formation as a result of cold air drainage and re-radiation (Figure 1, Table 1). These frosts

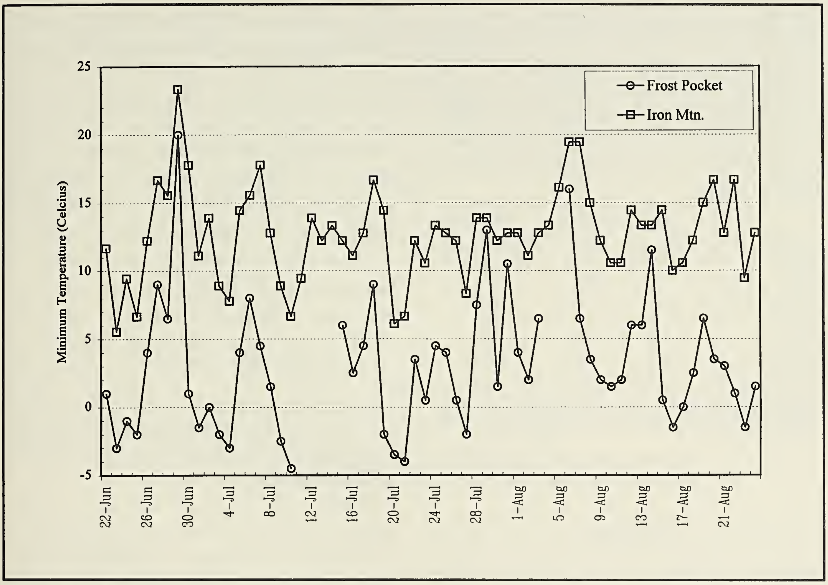

Figure 1. Minimum temperature patterns between a kettle (frost pocket) at the study site and nearest (*c.* 6 km) weather station (Iron Mountain) for the summer of 1996.

may then be referred to as a form of disturbance, which restricts recruitment of woody species in low areas of the landscape. Interestingly, bracken fern is also frost sensitive and restricted from the low kettles and valleys (Nielsen 1997). Therefore, bracken fern itself cannot influence the relative openness and stability of frost pockets (Vogl 1964*a*). It is likely that both competition and extremes in temperature exert an influence, with bracken fern competition acting according to an inhibition model of succession (Connell and Slayter 1977) and the microclimate functioning as a factor influencing recruitment based on frost sensitivity.

Because bracken-grasslands have rarely been studied (however, see Vogl 1964*a*), particularly in relations to the surrounding communities, first understanding which species are present to an area and why, may prove essential in understanding the communities' origins, ecology, and possible future management. In other Midwest savannas, variables such as soils, topography, and canopy have been found to be important determinants of species distributions (Bray 1958, Ware et al. 1992, Leach 1994, Pruka 1994, Hujik 1995). It is our objective here to determine patterns of plant species distributions along the major environmental gradients of canopy, soil organic matter, pH, soil nutrient index, slope position, and site severity index. Additionally, since the importance of bracken fern in this system may be quite substantial, responses of plants to densities of bracken fern fronds are examined.

Table 1. Minimum temperature (°C) patterns for Iron Mountain Weather Station and two data loggers located in a frost pocket and ridge top at approximately a 30 m difference in elevation. Data loggers were located at a 0.5 m height and placed out between 22 June and 24 August of 1996 (n = 58).

Statistic	Frost Pocket	Ridge Top	Iron Mtn. Weather Sta.
Mean*	3.1 [a]	8.3 [b]	12.7 [c]
Standard Error	0.7	0.6	0.6
Median	2.3	8.5	12.8
Minimum	- 4.5	- 0.5	5.6
Maximum	20	22	23.3
Number frosts	16	3	0

*Means ±SE are not significantly different if labeled with the same letter

Methods

Study Site

Field research was conducted at Spread Eagle Barrens State Natural Area, located c. 7 km southeast of Florence, Wisconsin (45°52′N, 85°10′W). This landscape size Natural Area occupies 3,580 ha, being bordered by the Menominee River to the east and approximately dissected in half by the Pine River. An ecological classification of the site in *Ecoregions of North America* (Bailey and Cushwa 1981) identifies Spread Eagle Barrens as a humid temperate domain, humid warm-summer continental division, and Laurentian mixed-forest province. The climate of the area is intermediate between lake moderated and continental, with a mean annual temperature of 5.2°C and a median frost-free period of 113 days. Mean annual precipitation is 739 mm with an average annual snowfall of 1,595 mm.

Elevations of the study area range from 385 to 320 m and form a distinct hummocky appearance. This topographic variation, called pitted outwash, was caused by collapsing sediment of proglacial streams deposited on stagnant glacial ice (Hadley 1976, Clayton 1986). The glacial advance responsible for this formation has been aged at approximately 12,300 years ago and is called the Early Athelstane Advance. This is a Silver Cliff member of the Kewaunee Formation of the late Wisconsin glaciation (Clayton 1986). The depths of these Pleistocene sediments vary from 76 m around Sand Lake to 16 m near the Menominee River. Soils are Spodosols with textures varying from sandy loams to loamy sands and characterized by a low pH (μ = 4.87 SE ± 0.02).

Historically, prior to European settlement, Spread Eagle Barrens was dominated by *Populus tremuloides* (quaking aspen), *Pinus banksiana* (jack pine), and *Betula papyrifera* (white birch) (Table 2) (Nielsen 1997). Today, however, many of the sites have been converted through management (logging and prescribed burning) to large homogenous bracken-grasslands, originally intended to optimize habitat for sharp-tail grouse. One region that escaped much of this management is the area surrounding Sand Lake. This area still maintains a rich mosaic of northern dry forests and bracken grasslands, perhaps because a wildfire swept the area in the late 40s or early 50s. Research was concentrated in the area surrounding Sand Lake because the existence of bracken-grasslands was not a function of management and because of the large variability there in site characteristics and competition across the landscape. In that vicinity we could investigate species responses to the landscape variables without having to account for recent management related effects.

Table 2. Numbers and frequencies of witness trees for Spread Eagle Barrens, listed by common names and Linnaean taxanomic equivalents.

Common Name	Scientific Name	Total Witness Trees	# Survey Points	Survey Point Frequency[a]
Aspen	*Populus tremuloides* or *Populus grandidentata*	40	25	44.6
White birch	*Betula paperifera*	26	17	30.4
Jack pine	*Pinus banksiana*	28	16	28.6
Red pine	*Pinus resinosa*	9	8	14.3
White pine	*Pinus strobus*	9	6	10.7
Spruce[b]	*Picea glauca* or *Picea mariana*	8	3	5.4
Maple[c]	*Acer saccharum* or *Acer rubrum*	1	1	1.8
White cedar	*Thuja occidentalis*	1	1	1.8
Oak	*Quercus ellipsoidalis*	1	1	1.8
Total		**123**		

[a] Survey point frequency represents the frequency of tree species to survey point. Since the survey points had between 2 and 4 witness trees, the sum of the frequencies exceed 100%.
[b] It appears that the surveyor did not distinguish between *Picea glauca* and *Picea mariana.*
[c] It appears that the surveyor did not distinguish between *Acer saccharum* and *Acer rubrum.*

Field Methods

In investigations dealing with distribution patterns of populations, a systematic grid design may allow for greater precision in analyses (Brown and Ruthery 1993). Therefore, in the summer of 1996, within the Sand Lake region of Spread Eagle Barrens, six 250 m^2 cells were randomly selected from an overlaying grid on a United States Geological Service 7.5 minute quadrangle. Within each of these six cells, 50 random observation points were chosen for sampling, producing a sample size of 300. Sites were sampled once between the dates of July 10th and August 20th of 1996. Each sample consists of a 1 m^2 circular herbaceous quadrat centered over the random position previously determined. Within this quadrat all living ground-layer plant species (<1 m height) were recorded for presence or absence based on taxonomy following E. G. Voss (1972, 1985, 1996). Along with plant presence or absence, the number of live bracken fern fronds was counted within each quadrat. To determine canopy coverage of a site, the line intercept method was used over a 10 m transect, which was centered over each quadrat (Haney and Apfelbaum 1994). In this method, a vertical plane was projected from the transect with the starting and stopping positions of tree species recorded.

Soil characteristics of each sample point were based on a composite soil sample from around each quadrat by combining four soil cores, each being 2 cm x 15 cm in size, from the major cardinal sectors of the quadrat. Samples were analyzed by the University of Wisconsin-Marshfield Soil and Forage Analysis Laboratory for organic matter, pH, P, K, Ca, and Mg. For the cations (P, K, Ca, and Mg), an index (nutrient index, NI) was created in order to reduce both the number of variables and the multi-collinearity between variables. This was done by ranking (ascending) each soil variable and summing the rank values.

The influence of topography was addressed by two complex gradients. The first is an index relating aspect and slope to incoming solar radiation. In both temperate and boreal zones, both aspect and slope combine to influence vegetation patterns caused by differences in solar radiation. Solar radiation has not only been found to influence vegetation patterns (Haase 1970, Fralish 1988, Bonan and Shugart 1989), but also soil moisture and forest productivity (Beers et al. 1966). Therefore, an index was created for this study called "site severity index" (SSI), which takes into consideration both aspect and slope, thereby representing the amount of direct solar radiation and heating of a site in relation to flat surface.

This index was modified from one created by Beers et al. (1966), which is based on a sine wave varying according to aspect. This gave maximum values for northeast slopes (productive forests) and minimum values for southwest slopes (unproductive forests). Other studies within the Midwest (Ware et al. 1992, Thomas and Anderson 1993) have used this function to investigate the influence of aspect on vegetation. In this study, however, the Beers' equation was modified so that a southwest slope received the highest value and a northeast slope the lowest, while being scaled between +1 and -1, representing xeric to mesic sites respectively. In addition, the function was scaled to take into account the amount of slope. As slope decreases from a high of 45%, the wave dampens toward zero, representing a flat surface. In the field, slope was recorded with a clinometer, while aspect was determined with a compass. Using these values, the site severity index was determined through the equation SSI = sin(A + 225) x (% slope/45), where A represents degrees from polar north and % slope from horizontal.

The second topographic variable examined was slope position. For this, each sample location was placed into one of six slope positions based on a visual inspection of the landscape. Slope position categories were as follows: frost pockets and valley bottoms (5), lower one third of slopes (4), middle one third of slopes (3), upper one third of slopes (2), narrow ridge (< 50 m wide) (1), and lastly a broad ridge or plain (> 50 m wide) (0).

Statistical Analyses

To determine species responses along examined gradients, logistic regression was used on presence/absence data of common (>10% frequency) ground-layer species in 1 m^2 quadrats (Appendix A). The logistic regression statistic is similar to linear regression except that the dependent variable (Y) is binary (1 or 0, hence present or absent) instead of continuous (Sokal and Rohlf 1995). Logistic regression then relates the proportions of a dependent variable to an independent variable. This independent variable can be continuous or discontinuous. Significance was considered at the level of $P < 0.10$ for the chi-square statistic. The modeling technique used here is one variant of GLM (general linear modeling) and is similar to analyses of *Eucalyptus* species in Australia by Austin et al. (1990).

For logistic regression modeling, a total of 34 species were tested in order across all six gradients of interest (canopy, NI, soil organic matter, pH, slope position, and SSI). In addition to the standard linear responses, which represent an increase or decrease in probability of that species across a variable, additional combinations were tested by adding quadratic and cubic functions. The quadratic function would indicate a Gaussian or Normal distribution, which is expected in ordination analyses. This type of response has been called Gaussian logistic

Table 3. Gradient partitions used for determining patterns of species optimal responses across examined gradients of topoedaphic factors, bracken fern (a), and canopy (b).

[a] Gradient Variable	Low	Mid	High	[b] Community Classification	Canopy Interval (%)
Soil O.M.	<2.6	2.6–4.0	>4.0	Forest	>85
Soil pH	<4.9	4.9–5.6	>5.6	Woodland	<85–>50
NI	<28	28–46	>46	Savanna	<50–>1
SSI	<-0.34	-0.34–0.34	>0.34	Grassland	<1
Slope position	4,5	2,3	0,1		
Bracken density	<9	9–18	>18		

regression (GLR) by ter Braak (et al. 1986). The cubic function would verify a more complex response, such as bimodal distributions. All gradients were examined for each species in histograms, in order to determine if these higher order functions were appropriate in the logistic model.

After modeling, probability responses for every significant species were plotted across the selected gradient. These gradients were then subjectively divided into sections to determine guilds of species (Table 3a). For these divisions, canopy was the only variable that was not segmented into equal proportions, in order to correspond to existing abstract community definitions based on canopy amounts (Table 3b). Since species are responding across gradients in a continuum fashion, these segmented divisions are to be used only for generalizations.

Results

Canopy

The canopy variable examined was the most important gradient overall, as determined by chi-square significance tests. All 34 species examined showed significant responses to this inferred light gradient. The majority of species response models were linear, followed by quadratic, and finally cubic functions (Table 4, Figure 2a). Along this gradient, four main segments were arbitrarily stratified for determination of optimal position according to community classifications following canopy amounts. Most species modeled were forest species, followed by the grassland guild, woodland guild, and savanna guild. The species that optimized their probabilities in the canopy range associated with the savanna classification include *Apocynum androsaemifolium, Comandra umbellata, Comptonia peregrina, Prunus pumila,* and *Vaccinium pallidum* (Table 5).

Nutrient Index (NI)

Nutrient Index represents the combinations of the relative ranks of available nutrients P, K, Ca, and Mg. This was the least predictive gradient in describing species responses; only 14 species were significantly related to it (Table 4). Of the significant models, most were linear, followed by a few quadratic, and only one cubic function (Figure 2b). Optimal positions tended to occur at the high end of the nutrient index, with a few in the middle and a few at the low end (Table 5). One of the species that optimized low nutrient sites, *Comptonia peregrina,* is a non-Leguminosae nitrogen fixer and perhaps an important early

Table 4. Functions used in logistic regression analyses of species along each gradient. Significance of each model is indicated as a subscript in each function.

Species	*Canopy*	*Nutrient Index*	*Organic Matter*	*pH*	*Topographic Position*	*Severity Index*	*Bracken Densities*
Acer rubrum	^{c}C	^{a}N		$^{a}P+P^{2}$	$^{c}T+T^{2}$		$^{c}B+B^{2}+B^{3}$
Agropyron trachycaulum	^{c}C			^{c}P	$^{c}T+T^{2}$		$^{c}B+B^{2}+B^{3}$
Amelanchier spp.	^{a}C	$^{a}N+N^{2}$					
Anemone quinquefolia	^{c}C		$^{b}O+O^{2}$		$^{b}T+T^{2}$	^{a}S	^{b}B
Apocynum androsaemifolium	$^{c}C+C^{2}+C^{3}$			^{b}P	$^{b}T+T^{2}+T^{3}$	^{a}S	^{c}B
Aster ciliolatous	^{c}C	^{a}N	$^{a}O+O^{2}$	^{c}P	$^{b}T+T^{2}$	^{a}S	
Aster macrophyllus	^{c}C	^{c}N	^{a}O	$^{a}P+P^{2}$	$^{c}T+T^{2}$		$^{b}B+B^{2}+B^{3}$
Bromus kalmii	^{c}C		$^{a}O+O^{2}$	^{c}P	^{c}T		$^{c}B+B^{2}+B^{3}$
Calystegia spithamaea	^{c}C				$^{b}T+T^{2}+T^{3}$	$^{b}S+S^{2}+S^{3}$	^{b}B
Campanula rotundifolia	^{c}C		^{a}O	^{c}P	$^{c}T+T^{2}+T^{3}$	$^{a}S+S^{2}+S^{3}$	$^{c}B+B^{2}+B^{3}$
Carex pensylvanica	$^{a}C+C^{2}+C^{3}$			^{b}P			
Comandra umbellata	$^{c}C+C^{2}$			^{a}P		^{a}S	$^{b}B+B^{2}+B^{3}$
Comptonia peregrina	$^{c}C+C^{2}$	^{c}N			$^{a}T+T^{2}+T^{3}$	^{a}S	^{c}B
Corylus cornuta	^{c}C		^{c}O	$^{b}P+P^{2}$	$^{c}T+T^{2}$	$^{c}S+S^{2}$	$^{b}B+B^{2}+B^{3}$
Danthonia spicata	^{c}C		^{a}O	$^{b}P+P^{2}+P^{3}$	^{c}T	^{c}S	^{c}B
Diervilla lonicera	^{a}C				$^{c}T+T^{2}$		$^{b}B+B^{2}$
Gaultheria procumbens	$^{c}C+C^{2}$		$^{a}O+O^{2}$	$^{b}P+P^{2}+P^{3}$	$^{c}T+T^{2}$	$^{b}S+S^{2}$	$^{c}B+B^{2}+B^{3}$
Hieracium aurantiacum	^{c}C		$^{a}O+O^{2}$	^{c}P	^{c}T	$^{a}S+S^{2}+S^{3}$	$^{c}B+B^{2}+B^{3}$
Lysimachia quadrifolia	$^{a}C+C^{2}$				$^{a}T+T^{2}$	$^{a}S+S^{2}+S^{3}$	
Maianthemum canadense	^{c}C	$^{b}N+N^{2}$	^{a}O	$^{a}P+P^{2}$	^{c}T	^{b}S	$^{b}B+B^{2}+B^{3}$
Melampyrum lineare	$^{c}C+C^{2}$			$^{a}P+P^{2}$			
Oryzopsis asperifolia	^{c}C	^{a}N	$^{b}O+O^{2}$	$^{c}P+P^{2}$	^{c}T	$^{b}S+S^{2}$	$^{b}B+B^{2}$
Poa spp.	$^{c}C+C^{2}$	^{a}N		^{c}P	$^{c}T+T^{2}+T^{3}$		$^{a}B+B^{2}+B^{3}$
Polygala paucifolia	$^{c}C+C^{2}$				$^{b}T+T^{2}$	^{a}S	$^{b}B+B^{2}+B^{3}$
Prunus pumila	$^{b}C+C^{2}$		^{b}O	^{c}P	$^{c}T+T^{2}$	$^{c}S+S^{2}$	$^{c}B+B^{2}$
Pteridium aquilinum	^{c}C	$^{a}N+N^{2}$	$^{c}O+O^{2}$	$^{c}P+P^{2}$	^{c}T	$^{a}S+S^{2}+S^{3}$	
Rubus allegheniensis	^{b}C	^{a}N			$^{a}T+T^{2}$	$^{a}S+S^{2}+S^{3}$	
Schizachne purpurascens	^{c}C		$^{a}O+O^{2}+O^{3}$	$^{b}P+P^{2}+P^{3}$	^{a}T		$^{c}B+B^{2}+B^{3}$
Trientalis borealis	^{c}C		^{a}O	^{b}P	$^{a}T+T^{2}$	$^{c}S+S^{2}$	$^{a}B+B^{2}$
Vaccinium angustifolium	$^{b}C+C^{2}$	^{a}N		$^{a}P+P^{2}$	^{c}T		$^{c}B+B^{2}$
Vaccinium myrtilloides	$^{a}C+C^{2}$		$^{b}O+O^{2}$	$^{a}P+P^{2}$			
Vaccinium pallidum	$^{c}C+C^{2}$	^{c}N					
Viola adunca	^{c}C	$^{a}N+N^{2}+N^{3}$		^{c}P	^{b}T	$^{a}S+S^{2}+S^{3}$	$^{c}B+B^{2}+B^{3}$
Waldsteinia fragarioides	^{c}C	^{a}N	$^{b}O+O^{2}$	$^{c}P+P^{2}$	^{c}T	^{b}S	$^{b}B+B^{2}$

Model chi-square = $^{a}P<0.10$, $^{b}P<0.01$, $^{c}P<0.001$

Table 5. Optimal positions for significant species as determined from logistic regression models.

Species	Canopy	Nutrient Index	Organic Matter	pH	Slope Position	Severity Index	Bracken Densities
Acer rubrum	100	62		4.8	1		28
Agropyron trachycaulum	0			6.3	5		21
Amelanchier spp.	100	35					
Anemone quinquefolia	100		2.1		3	-1	0
Apocynum androsaemifolium	34			4.2	0	-1	28
Aster ciliolatous	0	62	2.4	6.3	5	-1	
Aster macrophyllus	100	62	5.5	4.7	1		28
Bromus kalmii	0		5.5	6.3	5		0
Calystegia spithamaea	0				0	-1	28
Campanula rotundifolia	0		1.1	6.3	4	-1	0
Carex pensylvanica	69			6.3			
Comandra umbellata	33			6.3		-1	18
Comptonia peregrina	12	12			0	1	28
Corylus cornuta	100		5.5	4.6	1	-0.4	5
Danthonia spicata	0		1.1	6.3	5	1	0
Diervilla lonicera	100				1		28
Gaultheria procumbens	83		3	4.7	0	-0.37	7
Hieracium aurantiacum	0		5.5	6.3	5	-1	11
Lysimachia quadrifolia	100				3	1	
Maianthemum canadense	100	41	5.5	4.7	0	-1	28
Melampyrum lineare	56			4.7			
Oryzopsis asperifolia	100	62	3.5	4.7	0	-0.16	28
Poa spp.	0	62		6.3	5		21
Polygala paucifolia	54				4	-1	9
Prunus pumila	36		5.5	6.3	3	1	0
Pteridium aquilinum	100	35	3	4.5	0	0.04	
Rubus allegheniensis	100	62			2	1	
Schizachne purpurascens	0		5.5	5.2	5		19
Trientalis borealis	100		1.1	4.2	3	-0.59	28
Vaccinium angustifolium	52	12		4.6	0		28
Vaccinium myrtilloides	53		3.4	4.8			
Vaccinium pallidum	28	12					
Viola adunca	0	12		6.3	5	-1	0
Waldsteinia fragarioides	100	62	3.3	4.7	0	-1	28

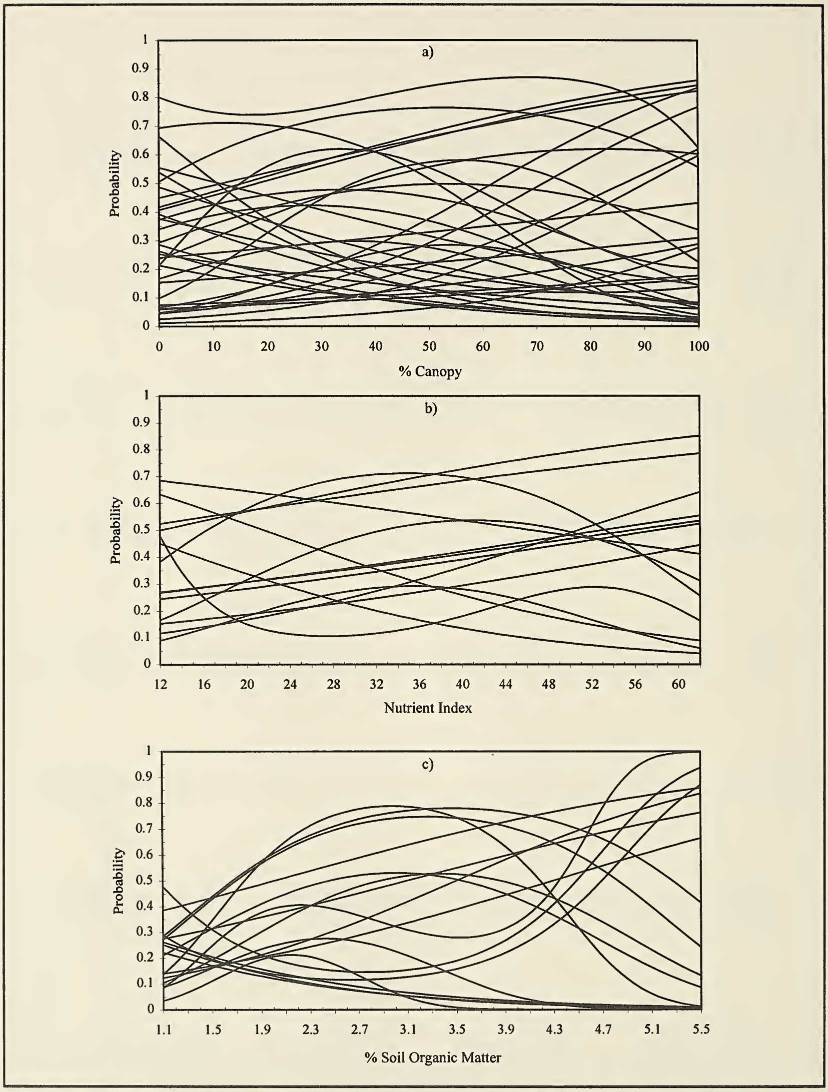

Figure 2. Responses of significant species, as determined by logistic regression, showing shape, optimal position, and distribution patterns of species across the gradients of canopy (a), nutrient index (b), soil organic matter (c), pH (d), slope position (e), site severity index (f), and bracken frond densities (g).

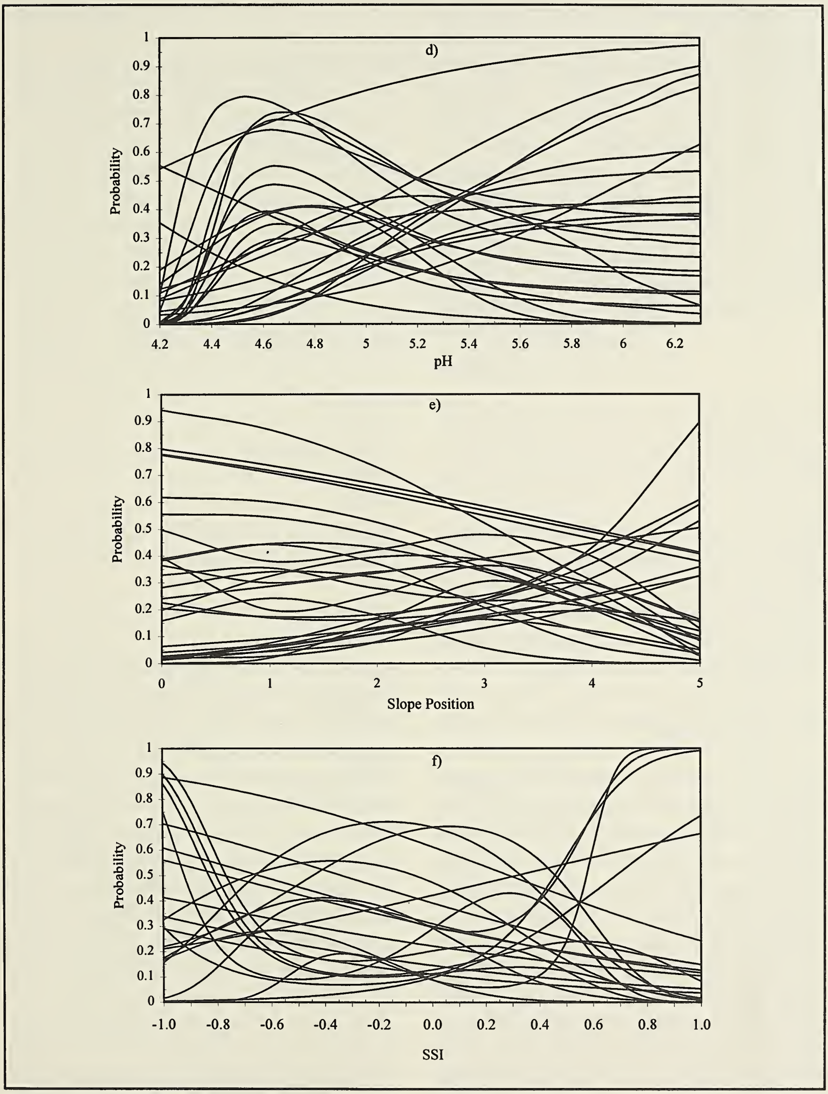

Figure 2, continued.

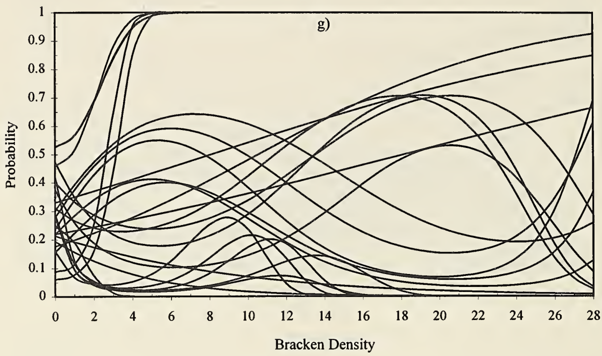

Figure 2, continued.

successional species for nutrient accumulation in these nutrient poor sandy soils. The significant *Vaccinium* species also maximized their position in these sites, which corresponds to the general patterns of Ericaceae species world wide.

Soil Organic Matter

Half of the species modeled were significantly affected by this gradient (Table 4). Species response models were primarily quadratic and linear, with only one being cubic (Figure 2c). Species optima tended to occur in both the mid and high ranges of the gradient, with only a few occurring in the low portion (Table 5). The species most likely to occur in low soil organic matter sites were the species *Campanula rotundifolia, Danthonia spicata,* and *Trientalis borealis,* while species such as *Corylus cornuta, Hieracium aurantiacum, Maianthemum canadense, Prunus pumila,* and *Schizachne purpurascens* tended to optimize probabilities in high soil organic matter. There does not appear to be any patterns between the two guilds.

pH

Most species were significant along this gradient (Table 4). For this variable, however, both logarithmic scaling and arithmetic equivalents were used. The species response types, then, turned out to be balanced between linear and quadratic functions (Table 4, Figure 2d). The majority of species had optimal positions in the high pH range with only a few species in both the mid and low ranges, such as *Apocynum androsaemifolium, Trientalis borealis,* and *Vaccinium myrtilloides* (Table 5). The species occurring with optimums in the high pH range were those associated with fairly open canopies (μ = 10.5% SE ± 7.4, n = 10) representing savanna communities, while species associated with low and mid pH ranges occurred in higher canopies (μ = 82.9% SE ± 7.4, n = 12) associated with forest communities.

Slope Position

This variable contained a high majority of significant models, indicating the importance of topography (Table 4). The response functions were again primarily quadratic and linear, with some complex cubic responses (Table 4, Figure 2e). Interestingly, most of the species had optimal positions in either the frost pocket/valley bottom or upland plains (Table 5). The upland plains' guild includes species such as *Apocynum androsaemifolium, Calystegia spithamaea, Comptonia peregrina, Gaultheria procumbens, Maianthemum canadense, Oryzopsis asperifolia, Pteridium aquilinum, Vaccinium angustifolium,* and *Waldsteinia fragarioides.* The frost pocket guild included such species as *Agropyron trachycaulum, Aster ciliatous, Bromus kalmii, Danthonia spicata, Hieracium aurantiacum, Poa* spp., *Schizachne purpurascens,* and *Viola adunca.*

The apparent difference between these two guilds is that the first guild (upland) is characterized by species typically found in northern dry forest and boreal communities (77.8%), while the second guild of species (frost pockets) are representative of a bracken-grassland communities (100%). This would point to the possibility that the topography variable of slope position may be critical in determining which community will occupy a site. Bracken-grasslands are found primarily in the kettles and valleys of pitted outwash, while forests tend to occupy the more upland positions.

Site Severity Index (SSI)

Site Severity Index was significant in explaining distribution patterns for many of the species (Table 4). A fairly balanced distribution of linear, quadratic, and cubic model functions were used (Table 4, Figure 2f). Optimal response patterns revealed that most species occurred on the mesic end of the gradient (SSI = -1), while a few species used the xeric (SSI = 1) and mid portions (Table 5). The xeric guild included the species *Comptonia peregrina, Danthonia spicata, Lysimachia quadrifolia, Prunus pumila,* and *Rubus allegheniensis,* which are common species to pine barrens and bracken-grasslands. The mesic guild contains species common to boreal forests, northern dry mesic forests, northern dry forests, and bracken-grasslands.

Bracken Fern

The change in bracken fern frond densities proved to play an important role in determining species distributions, with most species being significant (Table 4). Species responses were primarily cubic, with a fair number of both quadratic and linear functions (Table 4, Figure 2g). The cubic response may point to the complex interaction bracken fern may present to other species, with a set of interactions including allelopathy, nutrient competition, and light interception. Another possibility that may promote the unusually complex responses of species are that bracken clones are not at an equilibrium with the landscape. The clones are constantly invading outward with underground rhizomes at least 1 m in advance of emergent fronds (Watt 1940).

Regardless of bracken fern dynamics, a few species seem to respond positively to increasing bracken densities, which is interesting since bracken fern is thought to be an effective competitor and inhibitor (allelopathy). Most of the species showing positive responses to bracken densities (Table 5, Figure 2g), were also species that tended to have optima in high canopy conditions (μ = 72.5% SE ± 12.1, n = 11), while those that were negatively associated with increasing bracken densities tended to have optima in low canopy conditions (μ = 22.7% SE ± 16.6, n = 6). Thus, many typical forest species (northern dry forest) are located in the open bracken-grasslands. This distribution may partially be a function of bracken fern densities, with interception of light acting as a type of canopy. This, then, may infer advantages for species that can photosynthesize under low light conditions and hence may able to out compete species normally associated with the grasslands.

Discussion

Results indicate that canopy, topoedaphic variables, and bracken fern are all significant factors accountable for distribution patterns of plant species at Spread Eagle Barrens. Canopy appeared to be the most influential predictor for many species. Since canopy is also the easiest of the gradients to manipulate, a potential exists for management of desired species under certain conditions. Based on other environmental conditions, responses of species should be able to be predicted from logistic regression equations.

Topographic variables (slope position and site severity index) are often ignored. We found them to be key factors in determining both plant and community distributions. For instance, slope position influenced both community species patterns and individual species distributions. In particular, bracken fern, a keystone species, was most significantly related to slope position, presumably due to its frost sensitivity. Of the edaphic variables examined, both soil pH and % organic matter were influential for a number of species. However, the nutrient index created for the study was not related to the distribution of a majority of species.

Bracken fern had a cubic response in distribution models for many species. These responses suggest a complex relationship between bracken fern and other species, with the interactions of allelopathy, nutrient competition, and light interception being important. It was initially assumed that both allelopathy and competition would result in negative responses for many species, but our results indicate that the reverse was true. This may be explained by the fact that most positively associated species were those that would be classified as "forest" species, perhaps pointing to the importance of light interception by bracken fern.

According to Austin and Gaywood (1994), the ecological responses of species will be increasingly skewed toward the far ends of a gradient, representing the increasing role of physiological tolerance, while the center of the gradient will be dominated by responses of species occurring due to the increasing role of competition. The more superior competitors should then be found in the center of a gradient, resulting in high dominance and low diversity (Austin and Smith 1989). If this were the case, bracken fern, a noted competitor with high dominance, should be found in the center of direct gradients. This seems to be occurring for the variables of nutrient index, organic matter, pH, and site severity index at Spread Eagle Barrens. Removing or controlling bracken fern might produce an associated shift in species composition due to the releasing of competitive interactions. Bracken fern influence on species responses, including factors that influence bracken fern, are important considerations in the management of Midwestern Savannas. In fact, by selectively harvesting the woody species based on site characteristics that promote domination by bracken fern or within a frost pocket, maintenance may occur through competitive inhibition or the microclimate, instead of intensive management.

Appendix A. Species selected for logistic regression modeling based on frequency of occurrence (> 10%) within 1 m^2 herbaceous quadrats at Spread Eagle Barrens. Curtis fidelity represents the number of native communities, out of 34 identified, in which the species was found. The community maximum describes which plant community a species achieved maximum presence (Curtis 1959).

Genus	*Species*	*Family*	*Common Name*	*Curtis Fidelity*	*Community Maximum*
Acer	*rubrum*	Aceraceae	red maple	12	NDM
Agropyron	*trachycaulum*	Gramineae	wheatgrass	9	BG
Amelanchier	spp.	Rosaceae	serviceberry		
Anemone	*quinquefolia*	Ranunculaceae	wood anemone	18	NDM
Apocynum	*androsaemifolium*	Apocynaceae	spreading dogbane	18	ND
Aster	*ciliolatus*	Asteraceae	Lindley's aster	9	BG
Aster	*macrophyllus*	Asteraceae	large leaved aster	14	BF
Bromus	*kalmii*	Gramineae	Kalm's brome	10	BG
Calystegia	*spithamaea*	Convolvulaceae	low bindweed	11	ND
Campanula	*rotundifolia*	Campanulaceae	bluebell; harebell	14	CG
Carex	*pensylvanica*	Cyperaceae	Pensylvania Sedge	16	SDM
Comandra	*umbellata*	Santalaceae	bastard toadflax	21	OB
Comptonia	*peregrina*	Myricaceae	sweetfern	8	BG
Corylus	*cornuta*	Betulaceae	beaked hazlenut	9	BF
Danthonia	*spicata*	Gramineae	poverty oatgrass	5	BG
Diervilla	*lonicera*	Carpifoliaceae	bush-honeysuckle	17	BF
Gaultheria	*procumbens*	Ericaceae	wintergreen	13	ND
Hieracium	*aurantiacum*	Asteraceae	orange hawkweed	5	BG
Lysimachia	*quadrifolia*	Primulaceae	whorled loosestrife	8	PB
Maianthemum	*canadense*	Liliaceae	Canada mayflower	18	BF
Melampyrum	*lineare*	Scrophulariaceae	cow-wheat	4	ND
Oryzopsis	*asperifolia*	Gramineae	rice-grass	9	BF
Poa	spp.	Gramineae	bluegrass	10	BG
Polygala	*paucifolia*	Polygalaceae	gay-wings	6	ND
Prunus	*pumila*	Rosaceae	sand cherry		
Pteridium	*aquilinum*	Polypodiaceae	bracken fern	22	BG
Rubus	*allegheniensis*	Rosaceae	common blackberry	14	SD
Schizachne	*purpurascens*	Gramineae	false melic	8	BG
Trientalis	*borealis*	Primulaceae	star-flower	15	BF
Vaccinium	*angustifolium*	Ericaceae	low sweet blueberry	16	ND
Vaccinium	*myrtilloides*	Ericaceae	velvetleaf blueberry	11	NW
Vaccinium	*pallidum*	Ericaceae	hillside blueberry		
Viola	*adunca*	Violaceae	sand violet	8	BG
Waldsteinia	*fragarioides*	Rosaceae	barren-strawberry	8	ND

Acknowledgments

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Neal D. Niemuth and Mark S. Boyce

Disturbance in Wisconsin Pine Barrens: Implications for Management

Abstract *We compared cover, structure, and diversity of woody vegetation in three types of early successional habitat patches in the pine barrens of northwestern Wisconsin. Patch disturbance types included repeated prescribed burning, crown fire, and clearcutting. All three disturbances set back succession, but with distinct differences in vegetation structure and composition. Vegetation in patches created by crown fire had greatest tree density, diversity of structure and composition, and cover by jack pine and large woody debris. Differences in woody vegetation among disturbance types may influence the success of savanna restoration and landscape management projects at providing habitat for savanna wildlife species in the pine barrens.*

Timber harvest is frequently alluded to as a surrogate disturbance for fire in forested ecosystems because both reduce vegetative structure and/or create habitat harboring similar animal communities (e.g., Urban et al. 1987, Hansen et al. 1991, Hunter 1992, Sharitz et al. 1992, Vora 1993). Yet the relative effects of timber harvest on plant and animal communities are rarely quantified (but see Hansen et al. 1991, Fitzgerald and Tanner 1992, Greenberg et al. 1995).

In Wisconsin pine barrens, large-block timber harvest has been proposed as a landscape-level management tool that would create large habitat patches for area-sensitive grassland and shrubland bird species (Niemuth 1995, Parker 1995, Strand and Epperly 1995). Many grassland and shrubland bird species readily accept early successional habitat created by clearcutting in pine barrens (Niemuth 1995), although the relative effects of fire and clearcutting on pine barrens vegetation structure and composition are largely unknown.

Fire is the primary natural disturbance in the region (Curtis 1959), although pine barrens are also subject to catastrophic windthrow (Canham and Loucks 1984), ice storms (Vora 1993), and infestations of jack pine budworm (*Choristoneura pinus*; Volney and McCullough 1994). Before fire control began in the 1920s, recurrent fires swept the pine barrens, creating extensive openings largely devoid of trees (Norwood 1852, Murphy 1931, Curtis 1959, Vogl 1970). Because of fire control and tree planting, most of the region is currently forested, and timber production is the primary land use. Timber harvest is the dominant vegetation-removing disturbance in the pine barrens, as most wildfires are quickly extinguished and are limited in extent. However, early successional habitat is maintained in the region at four savanna reserves larger than 1,000 ha, along with several smaller reserves and fuelbreaks. Reserves are managed primarily to provide habitat for sharp-tailed grouse *(Tympanuchus phasianellus)*. Early successional vegetation is maintained at these reserves through frequent prescribed burning, which, over time, creates a vegetation community that may differ considerably from pre-settlement conditions (Mossman et al. 1991, Parker 1995).

We compared characteristics of woody vegetation in 40 patches created by crown fire, clearcutting, and repeated prescribed burning in northwestern Wisconsin pine barrens. We focused on structure of woody vegetation because woody vegetation is an important nesting and foraging substrate for wildlife (Niemuth 1995). In addition, structure of woody vegetation will be determined largely by management practices and disturbance type rather than by plant species' range and response to site characteristics. Our goal was to show how woody vegetation structure differed among disturbance types, as well as provide direction for future experimental analysis of vegetation response to disturbance in the pine barrens.

Materials and Methods

Study Area

Sampling took place during July of 1993 and 1994 in Burnett, Douglas, and Bayfield counties in northwestern Wisconsin (Figure 1). Pine barrens in the region are delimited by xeric, outwash sand soils; predominant tree species included jack pine *(Pinus banksiana)*, red pine *(P. resinosa)*, quaking aspen *(Populus tremuloides)*, big-toothed aspen *(P. grandidentata)* and red, Hill's, and burr oak *(Quercus rubra, Q. ellipsoidalis, and Q. macrocarpa)*. Oak, hazel (*Corylus* spp.), and cherry (*Prunus* spp.) shrubs were common in the openings we sampled. Typical ground cover included blueberry (*Vaccinium* spp.), sweet fern *(Myrica asplenifolia)*, bluestem (*Andropogon* spp.), and sedge (*Carex* spp.). The surrounding landscape primarily was forested, with timber production and recreation being the primary land uses.

Study Sites

Selection criteria included (1) location on outwash sand soils; (2) mean vegetation height visually estimated to be < 1.2 m; (3) creation or maintenance of opening by fire or clearcutting, rather than other management practices, frost, or edaphic conditions; (4) > 1 year since site was clearcut or burned; and (5) well-defined patch with forest > 5 m tall surrounding 90% of site. All known crown fire sites ($n = 4$) and savanna reserves ($n = 11$) within the region

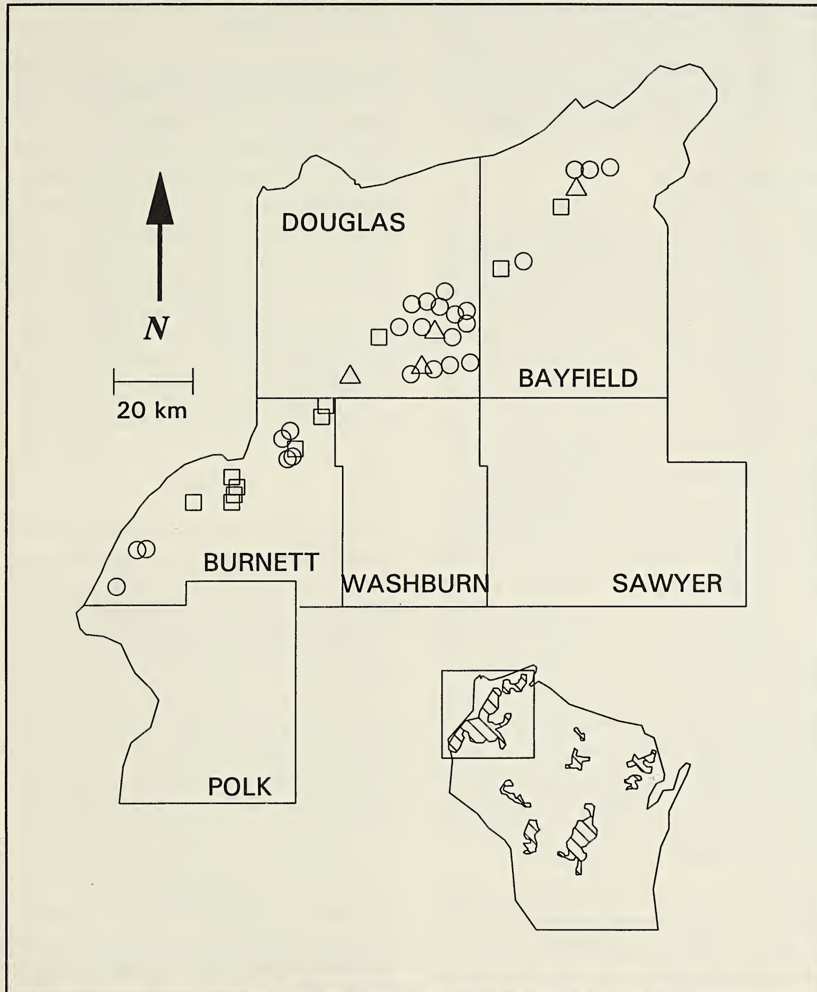

Figure 1. Location of sample sites. Squares represent savanna reserves; triangles represent openings created by wildfire; circles represent clearcuts. (Inset) Distribution of historic Wisconsin pine barrens, after Curtis (1959). Study took place within region bounded by square.

that fit these criteria were sampled. Known clearcut sites within the study region meeting selection criteria were stratified by size, and 25 were randomly selected (Figure 1). All sample sites were > 1 km apart.

Sampling Methods

Woody vegetation was sampled using the line intercept method (McDonald 1980). Intercept lines were 250 m long, although shortened intercept lines were used in seven patches that were too small to contain a 250-m sample line. Sampling of sites was proportional to patch size (n = 2 * log [estimated patch area in ha]), with the number of lines per patch ranging from one to eight. In patches containing multiple lines, sample lines were randomly placed off a systematically divided baseline with a random starting point. Height and intercept length were recorded for eight variables: percent cover by oak, pine, cherry, hazel, willow (*Salix* spp.), aspen, large woody debris, and dead standing trees of any species. Only woody vegetation > 0.5 m in height, length, or width was recorded. In addition, all live and dead trees > 12 cm diameter at breast height and within 10 m of the transect line were counted. Diversity of woody vegetation was calculated for each site using the Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{k} p_i \ln p_i$$

where k is eight and p_i is the proportion of line intercept coverage found in each of the eight woody vegetation covertype categories. Horizontal patchiness was calculated as the number of times woody vegetation cover types were encountered along a 250-m transect.

Statistical Analysis

We used direct discriminant analysis (SPSS Inc. 1990) to maximally differentiate line intercept data for the three patch types. We treat the discriminant analysis as descriptive, rather than a test of null hypotheses concerning differences among treatments because of inequality of the discriminant function variance-covariance matrices, lack of experimental control, and unknown management history (e.g., agricultural use, fire interval, pre-settlement vegetation, logging history). Descriptive statistics are presented to aid in understanding differences in woody vegetation among management types.

Results

The discriminant function created a two-dimensional ordination showing relative scores for the three patch types. The first discriminant function (Figure 2) accounted for 56.9% of the total variation in the data set and showed that greatest tree density, woody debris cover, and jack pine cover occurred at crown fire sites (means and standard deviations in Table 1). Savanna reserves scored lowest for these variables, and clearcuts were intermediate. The second discriminant function accounted for 34.2% of the total variation in the data set and showed that greatest height variation and Shannon-Wiener diversity were found in crown fire patches. Clearcuts scored lowest for these variables; savanna reserves were intermediate (Figure 2). Horizontal patchiness was greatest at savanna reserves and lowest in clearcuts. Greatest correlation between variables included in the discriminant analysis was 0.42. Category classification success in the discriminant analysis ranged from 75% to 92%, with an overall correct classification rate of 87.5% (Table 2).

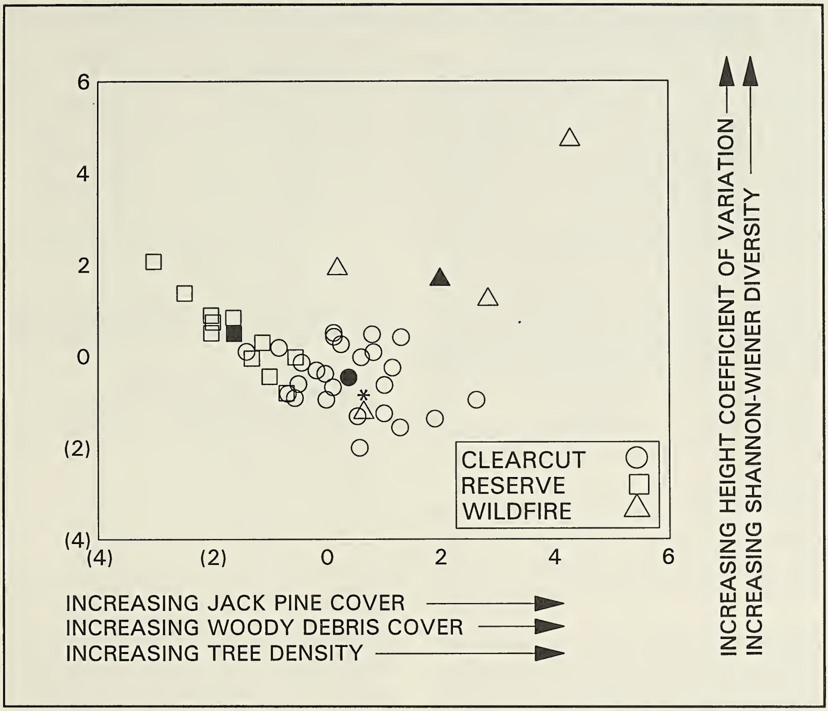

Figure 2. Woody vegetation discriminant function scores for 15 clearcut patches, 11 savanna reserves, and 4 wildfire-created savanna patches in northwestern Wisconsin pine barrens. Solid symbols represent centroids for each group. Triangle with * represents the Loon Lake wildfire, which burned twice in 11 years.

Discussion

Relative Effects of Disturbance Type on Vegetation Structure and Pine Barrens Wildlife

The most obvious difference among the three patch types was greater density of trees at crown fire sites than managed or clearcut sites. Trees, whether dead or alive, are an important habitat component in the pine barrens. For example, tree density is a significant predictor of Eastern bluebird *(Sialia sialis)* and tree swallow *(Tachycineta bicolor)* presence in Wisconsin pine barrens savanna; conversely, other savanna species such as the horned lark *(Eremophila alpestris)* and vesper sparrow *(Pooecetes gramineus)* prefer areas of lower vegetation (Niemuth 1995).

Differences in tree quality for nesting and foraging may also exist among the three disturbance types. The few trees that remain at savanna reserves are generally oaks and red pine that are sufficiently large to survive

Table 1. Mean (± standard error) of vegetation and structure variables at three patch types in Wisconsin pine barrens.

	Disturbance Type		
Variable	*Wildfire*	*Clearcut*	*Reserve*
Trees/0.5 ha	20.36 ± 3.9	3.11 ± 1.6	0.88 ± 2.36
Large woody debris (%)	7.69 ± 1.7	7.98 ± 1.6	0.65 ± 0.21
Shannon-Wiener diversity	1.32 ± 0.16	1.24 ± 0.06	1.31 ± 0.09
Height coefficient of variation	0.82 ± 0.11	0.66 ± 0.04	0.76 ± 0.07
Jack pine cover (%)	7.94 ± 4.2	1.97 ± 0.6	0.11 ± 0.07
Patchiness (intercepts/transect)	117 ± 41	90 ± 17	197 ± 25

Table 2. Classification results for predicted group membership of three patch types based on discriminant analysis. Percent correct for each group in parentheses; 35 (87.5%) of 40 cases were correctly classified.

		Predicted Group Membership		
Actual Group	*Number of Cases*	*Clearcut*	*Savanna Reserve*	*Wildfire*
Clearcut	25	23	2	0
		(92)	(8)	(0)
Savanna reserve	11	2	9	0
		(18.2)	(81.8)	(0)
Wildfire	4	1	0	3
		(25)	0	(75)

repeated prescribed burns (pers. obs.). But crown fire patches were dominated by injured and dead trees, which typically have different physical attributes than live trees. Sloughing bark on dead trees provides cover for invertebrates and foraging sites for bark-gleaning birds, and rotting wood hosts invertebrates and simplifies excavation by primary cavity nesters (Evans and Conner 1979, Cline et al. 1980, Mannan et al. 1980).

Woody debris is also an important component of pine barrens vegetative structure. Woody debris provides escape cover, foraging habitat, and perch sites for many bird species (Mossman et al. 1991). Nests of Brewer's blackbirds *(Euphagus cyanocephalus)* and brown thrashers *(Toxostoma rufum)* are frequently associated with woody debris in pine barrens, and black bears *(Ursus americanus)* regularly turn over and tear apart large woody debris in search of food (pers. obs.). Woody debris is also an important substrate for fungi and provides cover for invertebrates and small vertebrates (Zappalorti and Burger 1985, Gillis 1990, Hansen et al. 1991, Haim and Izhaki 1994). In addition to providing cover for wildlife, woody biomass is an important nutrient reservoir in pine ecosystems (Boerner 1982). The relative scarcity of woody debris at managed sites is apparently caused by repeated prescribed burns with relatively little time for regeneration of woody vegetation between burns.

Density of jack pine varied greatly among the three patch types. Jack pine density was greatest at crown fire sites, where serotinous cones opened in response to fire. Some jack pine cones in the region open in response to high ground temperatures (D. Epperly, pers. comm.), allowing jack pine regeneration in many clearcut patches. Repeated burns eliminate age cohorts of jack pine before regeneration can occur (Anonymous 1931, Vogl 1970), explaining extremely low jack pine densities at managed savanna reserves. Curtis (1959) described the jack pine as the most usual tree on the pine barrens, yet management practices intended to perpetuate savanna have virtually eliminated jack pine from savanna reserves.

Fire frequency strongly influences structure and composition of vegetation at a site. For example, the Five-Mile Fire burned approximately 5,400 ha of jack pine-dominated forest in northwestern Wisconsin in 1977 (Gregg 1987). Jack pine quickly regenerated following the fire, and most of the area was soon covered with dense growth of jack pine saplings. Without further disturbance, jack pine at the site would have grown to maturity. But in June 1988, the Loon Lake Fire burned a portion of the Five-Mile Fire. Jack pines were eliminated from that patch, and the Loon Lake Fire became a brush prairie, with characteristics similar to clearcuts in the area (Figure 2).

Fire frequency also affects densities of blueberries, which provide food for wildlife and humans. Blueberry cover was greatest at crownfire sites and lowest at managed savanna reserves (Niemuth 1995). Burning stimulates blueberry growth (Murphy 1931, Vogl 1970), but Buell and Cantlon (1953) found that blueberry cover decreased at their New Jersey study site when burns became more frequent than every three years.

Clearcuts had reduced Shannon-Wiener diversity and height range of woody vegetation, which may negatively impact many savanna wildlife species. For example, species richness and density of savanna birds along transects are positively correlated with Shannon-Wiener diversity of woody vegetation in early successional habitat in the pine barrens (Niemuth 1995).

Management Implications

Altering management practices can address some of the differences in which clearcuts and savanna reserves differed from crown fire patches. For example, tree density can easily be increased in clearcuts by leaving dead and live trees during timber harvest. Diversity of woody vegetation in clearcut patches could be increased by discontinuing management practices that reduce diversity such as release of young pines by removal of deciduous shrubs. Lengthening the return interval for prescribed fires at savanna reserves will allow added growth of woody vegetation and, over time, potential for more woody debris. With a longer fire return interval, trees can (1) grow larger and develop thicker bark, better enabling them to survive fire (see Vogl 1970) or (2) survive long enough to produce seed, permitting seedlings to regenerate even if parent trees are lost to fire.

Landscape-level management could add a dimension of spatial and temporal variability that is largely absent from present disturbance in the pine barrens. Presently, most clearcuts are small relative to proposed management (Parker 1995, Strand and Epperly 1995), leading to habitat fragmentation. Also, savanna reserves in Wisconsin pine barrens are spatially static, and vegetation is burned approximately every five years.

Temporal variation in disturbance was noted by Vogl (1964), who observed that "brush prairie savanna undoubtedly reverted back and forth from brush to forest and forest to brush again, depending on the absence or presence of fire." Depending on the time of observation, a site might accurately have been described as brush prairie, pine savanna, or forest. Indeed, such variation would have influenced the pre-fire vegetation at crown fire sites we sampled, influencing post-fire characteristics to which we compared vegetation at prescribed burn and clearcut sites.

Of course, fire is not the only factor shaping the pine barrens. Vogl (1970:200) noted that "all factors including soil type, soil fertility, topography, climate, drought, and fire are inseparably linked. . . . Fire is one of the essential ingredients . . . but the critical factor . . . is not so much fire, but the presence of sandy plains; sites with low fertility that lend themselves to droughts and fires of the proper intensities and frequencies to produce a vegetational structure and composition called barrens." The myriad forces that shape pine barrens vegetation are too complex and variable for managers to duplicate, illustrating a key problem experienced at many nature reserves: trying to preserve that which changes (White and Bratton 1980).

The influence of disturbance on other processes and taxa in the pine barrens must also be considered. Our analysis demonstrated that disturbance type can influence the structure and composition of woody vegetation persisting after disturbance occurs. But disturbance size and intensity can also alter the trajectory of succession, influencing composition and growth form of vegetation established following disturbance (Canham and Marks 1985).

Duplicating pre-settlement conditions will be difficult, if not impossible, when the "natural" disturbance regime is unknown, but through active adaptive management and simulation modelling, habitat quality on managed landscapes can be improved (see Walters and Holling 1990, Boyce 1993, Hansen et al. 1993). An understanding of the range of vegetation types and disturbances in a dynamic ecosystem can guide management (Sprugel 1991). Management of the pine barrens, whether through timber harvest or prescribed burns at dedicated reserves, must reflect the dynamic nature of the ecosystem.

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Rebecca L. Power and Alan Haney

Adaptive Management: A Solution to Restoration Uncertainties

Ecosystem management has encountered two diametrically opposed areas of resistance, each with some merit in their arguments. On one hand, many prominent ecologists have argued that ecosystems are more complex than we understand (Egler 1977), and some believe that we lack sufficient knowledge to make good restoration decisions (Haney and Boyce 1997), at least when uncertainty is high. On the other hand, many natural resource professionals consider ecosystem management an affront to their ability to make proper management decisions (Rudzitis 1996). The latter believe they have been managing ecosystems well for decades and cite evidence of commodity increases, such as timber volume, or game numbers to justify past decisions. Those who argue that their management decisions have been within the limits of sustainability will usually acknowledge a lack of data pertaining to ecosystem processes or structure, including biological diversity. They may also point out that ecologists often disagree on the importance of various measures of sustainability, such as diversity. Baskin (1994), for example, concluded that the risks associated with biodiversity loss were largely unknown. More recently, Tilman (1997) reported both direct and indirect evidence that ecosystems become less functional as diversity is lost. We (Haney and Power 1996) previously suggested that adaptive management is an excellent model for guiding ecosystem decisions. Here, we offer an adaptive management model to guide ecosystem restoration. Adaptive management not only helps us address uncertainty, it offers an opportunity to validate and improve good management practices, including decisions not to intervene in natural processes.

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Restoration generally requires a more complex set of decisions than other types of management. For example, one is immediately confronted with the decision of whether to intervene, how, and to what extent, either by modifying natural processes or altering human impacts. Because they typically involve greater shifts in ecosystem processes or structures, these decisions tend to be more value-laden and controversial than those associated with ongoing ecosystem management. Consequently, a high level of social input is often needed to support the successful implementation of restoration plans. Aldo Leopold demonstrated remarkable foresight when he wrote in an unpublished essay in 1935 that "the inevitable fusion of these two lines thought [social science and natural science] will, perhaps, constitute the outstanding advance of the present century" (Bradley 1997). The adaptive management model proposed by Walters and Holling (1990) melds social issues with good scientific methods. We further develop it here for guiding ecosystem restoration decisions. We believe the adaptive management model, as we have applied it, addresses the concerns of those who might otherwise use a priori arguments to oppose ecosystem restoration, and other forms of ecosystem management.

Inventory and Information Exchange

Figure 1 is modified from our previous adaptive management model (Haney and Power 1996). High quality information and effective communications comprise the foundation for all management decisions (Figure 1). During the process of gathering and communicating information, goals and objectives for ecosystem management begin to emerge. Information is needed not only to set goals, but also to guide the acquisition of additional information. Managers must be creative in searching for sources of information; technical literature, historical documents, maps and survey notes, interviews, and focus groups are examples. It is especially important to solicit and involve stakeholders (those groups or individuals with a vested interest in management decisions) throughout the process.

The success of restoration, like other genres of ecosystem management, is dependent on the attitudes and agendas of people (Gunderson et al. 1995). Stakeholders are a storehouse of useful information for resource managers. This does not mean that resource managers should undervalue their own professional expertise. Exchanging information with stakeholders is an integral part of the process; however, using information wisely is probably the greatest art in ecosystem management.

Goals and Objectives/ Desired Future Condition

Goals and objectives are based on available information, including opinions and attitudes of stakeholders and assumptions or hypotheses to be tested. The Ecological Society of America Committee on Ecosystem Management identified clear operational goals and sound ecological models and understanding as the highest priorities in developing a comprehensive ecosystem management system (Christensen et al. 1996). For the purposes of this paper, goals are the overarching principles and guiding vision for proactive management (Figure 1). They are the desired future toward which management is directed. Objectives are the concrete actions that need to be taken to achieve goals. Goals determine the direction we will move, or where we will move, to achieve a desired condition. Objectives determine how

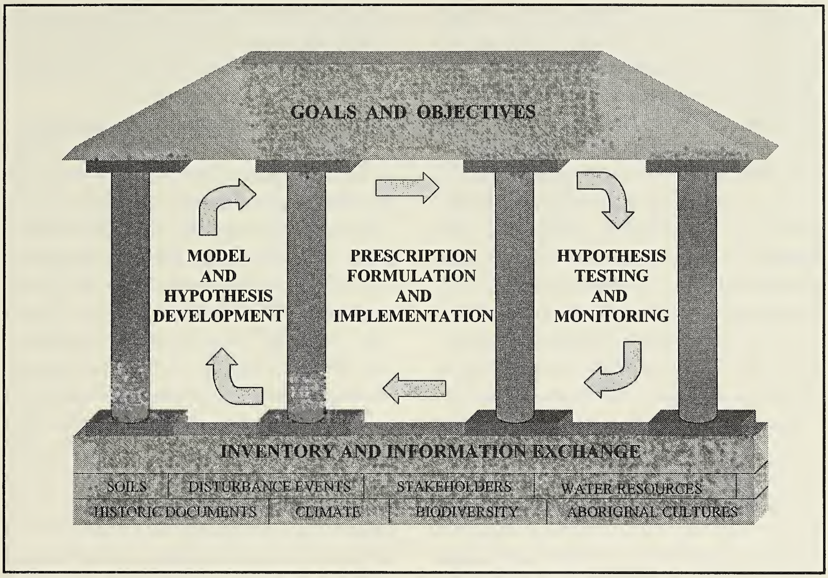

Figure 1. A conceptual model of adaptive management. Information is the foundation supporting the overarching goals and desired future conditions. The process, which stems from information and goals, involves model and hypothesis development, prescription formulation and implementation, monitoring, and hypothesis testing, in a continuous process.

we will move (U.S. Department of the Interior Fish and Wildlife Service, Division of Refuges 1996).

One should not worry excessively that insufficient information is available for setting goals and objectives. In fact, it is often the case that more information leads to greater uncertainty. For example, in overgrown savannas, canopy reduction results in an increase in total diversity and herbaceous diversity (Vogl 1964, Nuzzo 1986, Haney and Apfelbaum 1990, Stritch 1990), but there is much less information about the relative effects of different approaches to canopy reduction. Is timber harvest or mowing as effective as fire when the goal is to restore the herbaceous layer? What differences occur with annual fires of low intensity compared to less frequent intense fires? How does grazing compare to fire or mowing? How does fire affect various invertebrate populations? These and dozens of other questions arise continually as managers consider infinite alternative management approaches.

When information about stakeholder opinions is added, uncertainty increases even more. For example, managers have believed for years that fire is the best tool for maintaining savanna ecosystems. However, some stakeholders oppose fire (Swengel 1996). This dichotomy of opinions can be restated as one or more hypotheses, and the experiments to test the hypotheses can be incorporated into management plans (see Model and Hypothesis Development). Difficulties arise, not from acting on assumptions, but from lack of information about the validity of assumptions. Administrators, scientists, and other stakeholder groups may have different assumptions about the way that components of an ecosystem will respond to a treatment. In a roundtable discussion on biological diversity convened by the Chequamegon and Nicolet National Forests, Crow et al. (1994) found that an effective way to reach consensus, or at least diffuse potentially volatile disagreements, was to reduce points of contention to testable hypotheses. If stakeholders are involved in stating the hypotheses and designing the experiments to test them, they are more likely to become partners in the management of the ecosystem, rather than antagonists.

Because ecosystems provide many services for many constituencies (Daily 1997), inevitable conflicts of interest will arise. Gunderson et al. (1995) pointed out that consensus building is an essential part of adaptive management. Costanza and Folke (1997) laid out a 12-step process for consensus building leading to development of a scoping model that is helpful in showing how social values are related to ecological objectives. These steps are the primary tools for relating information to stakeholders. Stakeholders, in turn, often can contribute information useful in understanding an ecosystem or setting goals. For example, some may recall historic events of importance or conditions that once existed in the ecosystem. In soliciting this input, managers typically gain cooperation necessary for ecosystem management. The most obvious stakeholders are those who visit and use the ecosystem, but others include adjoining property owners, other neighbors, environmental and conservation groups, local schools, and staff who work on the property or for the managing organization.

People are sometimes fearful that misguided goals may lead to irreparable damage to the ecosystem. This is usually an exaggerated concern. Consider, for example, that most of the national forest land in eastern United States was once cleared and pastured or cultivated, then abandoned in lieu of taxes. Some of these acres are now wilderness, and most support productive forests (MacCleery 1993). Patric (1995) reported another remarkable illustration of ecosystem resilience. Two watersheds in West Virginia were matched for a study in which one was clearcut and kept barren for five years with regular application of herbicides. Now, 30 years later, essentially no difference in diversity or soil fertility can be found between the clearcut and herbicide-treated ecosystem and the control. Conversely, there are examples where goals and objectives not supported by sufficient information and monitoring have led to management decisions that compromised ecosystem sustainability. For example, doing nothing to counter successional degradation of savannas may result in long-term ecosystem damage, perhaps much more than inappropriate intervention. Apfelbaum and Haney (1991) reported that degraded mesic savannas in northern Illinois were losing topsoil in excess of 50 tons per acre per year. When restored, these savannas lost less than 5 tons of soil per year and supported plant and animal diversity that was approximately 10 times greater than unrestored savannas. This example also demonstrates the importance of coupling baseline data to continuing monitoring (Goldsmith 1991).

The inevitable uncertainties that cloud our view of the future necessitate testing hypotheses. Hypotheses and models will guide selection of the management alternatives that best accomplish desired outcomes.

Model and Hypothesis Development

Assumptions can be formally stated as hypotheses, then organized as models to indicate how the manager believes the system will respond. Model and hypothesis development is supported by information; they are part of the structure that supports goals and objectives (Figure 1). This is where sound science is coupled to restoration. Good management requires that we take time to state assumptions, develop underlying hypotheses, and design prescriptions to test those hypotheses. Every time a management decision is implemented, it is an experiment. A heuristic approach to management leads to a more objective basis for evaluating responses of the ecosystem. Often this is simply a matter of replicating treatments (prescriptions) and leaving controls, thereby providing a stronger statistical basis for evaluating responses and separating the influence of confounding factors, such as site histories and yearly variation in weather patterns (Goldsmith 1991). Through this process, science is employed to increase knowledge about the way the ecosystem responds. Furthermore, managers who participate in the scientific process will usually find willing scientists to partner with them; scientists who engage in dialogue with managers become more aware of management concerns and limitations.

In the adaptive management model, assumptions, which follow from uncertainties, are restated as hypotheses and models; these, in turn, drive prescriptions, and all drive monitoring. Therefore, the following issues need to be addressed during hypothesis formation.

System Components

The three primary elements that make up ecosystems being restored or managed are composition, structure, and function (Crow et al. 1994). Composition refers to the units that are present in a system. They can take the form of genes, species, cover types, cultures, communities, and ecosystems. Structural considerations address the size, shape, and patterns of distribution of compositional elements across space and time. Fire patches, return intervals, and how fire creates successional patterns at landscape scales are structural questions that might be addressed when developing savanna restoration models and hypotheses, for example. The functional elements of a system are process oriented. In the broadest view of ecosystems, we need to consider both the human and non-human components. Thus, predator-prey relationships, the dynamics of stakeholder interactions at public meetings, the way that disturbances such as insect outbreaks and disease influence fire return intervals and intensity, and carbon and nitrogen cycling are all functional aspects of ecosystems. Our management success is often more dependent on the social components than the non-human elements and should not be neglected. The ecosystem components are the framework around which models and hypotheses are developed.

Scale

Hypotheses can be formulated that address several scales of time and space. The concept of scale can be thought of as a nested hierarchy (Allen and Star 1982), with managers choosing to address different issues at different points, depending on their goals and objectives. The compositional, structural, and functional components of natural systems can be examined at the genetic, species, community, ecosystem, and landscape levels. The scale that managers choose significantly affects the information that results. For example, Knopf and Samson (1996) found that maximizing site (alpha) diversity may reduce regional (gamma) diversity in birds in western riparian areas. When diversity was low, river corridors supported species that were regionally less common. When diversity was higher, corridors supported a greater number of generalist species, sometimes to the detriment of rarer species. Likewise, local populations of bird species vary with vegetation structure (MacArthur and MacArthur 1961, Anderson and Ohmart 1977) and floristic composition (Holmes and Robinson 1981, Rotenberry 1985, Wiens 1989). This variation can be significantly affected by single disturbance events such as fire or flooding (Knopf and Sedgwick 1987). If hypotheses address only site diversity, population changes occurring at longer temporal scales can be obscured (Knopf and Sedgwick 1987). Therefore, both spatial and temporal scale must be considered when asking questions about ecosystems. Hypotheses can test for movement toward desired future conditions (goals) that encompass a range of conditions, rather that those that occur at one set point in time (Morgan et al. 1994).

Keystones or Indicators

The concept of keystones or indicators up until recently has been confined to organisms (Mills et al. 1993). Keystone species have wide-ranging effects on ecosystem composition, structure, and function, often greater that their numbers would suggest (Noss and Cooperrider 1994). There has been debate about the usefulness of the keystone species concept because of the potential to lose sight of the complexity of ecological interactions (Mills et al. 1993). However, deMaynadier and Hunter (1997) have expanded the keystone concept to include keystone ecosystems such as large rivers that serve as a fire breaks in savanna landscapes, and Holling (1992) discusses biotic and abiotic processes that have disproportionately large effects on ecosystem function. For example, in northern hardwood forests in the eastern United States, spruce budworm populations cycle every 30–40 years (Morris 1963). This cycle is driven by an interaction among the budworm, insectivorous songbirds, and trees (Holling 1988). The changes that occur in the forest as a result of this interaction cannot be understood by looking at spruce budworm population dynamics alone; understanding the dynamics of the northern hardwood forest ecosystem is contingent upon understanding the keystone process.

Prescription Formulation and Implementation

The best prescription will result from the most desirable outcome with the greatest probability of occurrence (Walters and Holling 1990). After hypotheses have been developed, management prescriptions should be written in a way that facilitates hypothesis testing. In the adaptive management process, a framework of goals and information supports both hypothesis development and prescription formulation. To ensure reliable knowledge, an experimental approach should be taken in developing and implementing prescriptions, using controls and replication as much as possible. If necessary, consult with scientists or statisticians within your own organization or develop a working relationship with academic institutions that can offer the appropriate technical assistance. Involvement of scientists supports the objectivity of management decisions and reassures stakeholders who question the goals or methods being implemented.

Initially, data are gathered to establish baseline conditions or provide background that is useful for setting goals. Baselines are often important to assess shifts in populations and processes and will be the foundation of the monitoring program. Therefore, presume that inventories will be repeated and develop protocols to facilitate re-surveying.

Partnerships may be useful, and opportunities to cultivate them should not be overlooked. Good working relationships often emerge from involvement of stakeholders. Faculty or students from local schools, environmental groups, or citizens from surrounding neighborhoods can assist in gathering and compiling information. For example, students and faculty from the University of Wisconsin-Stevens Point are involved in a regional savanna restoration project involving six different restoration sites in Wisconsin and Illinois, working with both public and private agencies. The students collected information for long-term restoration monitoring and conducted separate research projects related to the goals and objectives of their respective sites. Partnerships like this refine understanding of savanna restoration techniques, facilitate communication, enhance interest in the ecosystem, and add educational value to the project.

If the rest of the adaptive management process has been done well, the implementation of prescriptions is the most straightforward task in restoration. Involving stakeholders in restoration activities such as prescribed fire, brush and noxious weed removal, and seed harvesting help promote understanding and teamwork as well as getting the job done.

Even when stakeholders have agreed on ecosystem goals, they may differ in how best to achieve them. For example, we (Haney and Power 1996) hypothesized that the use of the oak wilt fungus *(Ceratocystis fagacearum)* might be used to reduce tree cover during oak savanna restoration (Collada and Haney, in press), but many stakeholders would strongly object to using it. Gypsy moths are effective in reducing woody vegetation, but neighbors and resource managers alike would likely object if these insects were introduced into a degraded savanna. Ideally, the majority of stakeholder groups should understand the ecosystem, share their opinions, and be involved in deciding future conditions and management actions. If necessary, employ conflict resolution to resolve differences before proceeding. Creative solutions are often possible. For example, timber sales followed by fire can be used to reduce woody biomass in overgrown savannas, thereby recovering economic value in the process and providing benefits to stakeholders who may otherwise object to restoration (Haney and Power 1996).

Although many stakeholders will have opinions about prescriptions, it is ultimately the responsibility of the manager to decide how to proceed. This is the art of ecosystem management. An implementation index is a way to assess the applicability of a prescription to a particular management situation. Table 1 is an example of an implementation index for treatment options for barrens restoration at Necedah National Wildlife Refuge. The political feasibility, technical feasibility, and efficacy ratings are based on conversations with stakeholders and past management experience. It is a model representing our best understanding

Table 1. Implementation index. Alternative treatments are evaluated according to political feasibility, technical feasibility, and efficacy. Values may be weighted to correspond to individual management situations.

Treatment Options	*Political Feasibility* (PF	+	*Technical Feasibility* TF)	x	*Efficacy* (E)	=	*Implementation Index* I
Timber removal	4		4		4		32
Prescribed fire	3		4		3		21
Herbivory	2		2		1		4
Insect introduction	1		4		1		5
Disease introduction	1		4		2		10
Herbicide	2		4		2		12
No treatment	5		5		1		10

of the way these treatment options interact with the current political climate, the Refuge's technical and logistical capabilities, and the composition, structure, and function of the ecosystem. The implementation index, I, is calculated as

$$I = (PF + TF) \times E$$

where PF = political feasibility, TF = technical feasibility, and E = efficacy. In the Necedah model, timber removal and prescribed fire had the highest indices and therefore were the preferred options. In addition, we know through previous management experience that these two treatments work better in combination than separately. I can also be calculated for combinations of treatments, when appropriate, as

$$I = [(PF_1 + PF_2) + (TF_1 + TF_2)] \times (E_1 + E_2)$$

For more discussion on the use of this index, see Haney and Power (1996).

Monitoring

Monitoring methods follow directly from the models and hypotheses being tested. Once restoration has begun, monitoring responses of the ecosystem to management activities facilitates the improvement of management techniques, increases understanding of the ecosystem and how it functions, and facilitates sharing objective results with stakeholders.

The adaptive management model is particularly useful in sorting through the myriad issues surrounding monitoring. Monitoring can address different scales of time and space, from the effects of heat on seeds in the soil at a particular point during a fire, to the survival of a cover type over an entire landscape. Monitoring programs have more rarely addressed the human dimensions of resource management. Stakeholder opinions and effects on the landscape both need to be included to achieve a sustainable desired future condition. (For more information about choosing variables to monitor, see Model and Hypothesis Development).

Noss and Cooperrider (1994) listed three types of monitoring necessary for adaptive management. Implementation monitoring keeps track of whether managers accomplished what they said they would. Unfortunately, some agencies do not get beyond implementation monitoring, which is rarely pertinent to hypothesis testing. Effectiveness monitoring, on the other hand, answers the question "Did the prescription meet its goal?" Validation monitoring goes farther and answers the question "How well did the prescription meet its goal?" It is this level of monitoring that is most useful for testing hypotheses. For example, songbird populations on a restored savanna were hypothesized to increase 10% because of an increase in structural diversity. Although effectiveness monitoring revealed that songbird populations did increase by 10%, validation monitoring indicated that the reason was actually an increase in the cover of warm-season grasses.

Issues of efficiency are also important when designing a monitoring program. Linking monitoring to hypothesis testing is the best way to make the use of limited resources. This ensures that the questions that need to be addressed to meet goals and objectives are first priority. Choosing keystone or indicator variables to monitor and integrating the elements of a biological monitoring program into nested units also increases efficiency. For example, we developed a biological monitoring strategy for Necedah National Wildlife Refuge (Figure 2). It integrates the monitoring components that we hypothesized were important for monitoring long-term change over time, as well as provides information about savanna habitat and associated species of concern. Monitoring plots will be randomly located in savanna habitats across the Refuge. Plant, invertebrate, avian, soils, and fire effects monitoring plots are all located around a single plot origin point. This strategy saves time and energy in

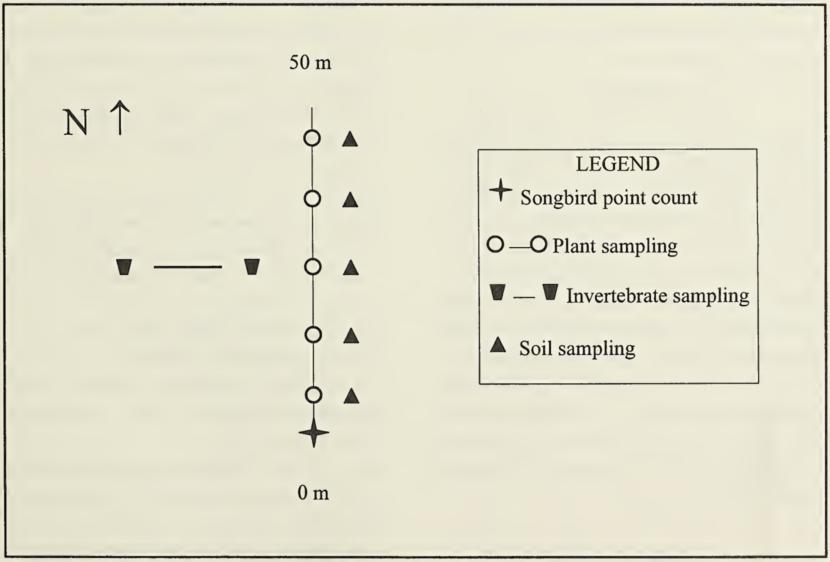

Figure 2. A biological monitoring plot at NNWR. Monitoring needs to provide the information necessary to test hypotheses, as well as evaluate responses of ecosystems to management activities.

documenting and traveling to plot locations, especially if field technicians vary from season to season. It also provides a clear, concise framework for explaining the program to others, especially to administrators for whom efficient use of time and money is a primary consideration. However, not all monitoring variables can be linked in this way, especially those dealing with human dimensions or rare species.

The final step is analyzing the data and sharing it with stakeholders. This begins the next cycle. At the very least, this increases the knowledge and understanding of stakeholders. In some instances information from monitoring may cause us to reconsider our goals, develop new models and hypotheses, modify prescriptions, and involve additional stakeholders. Thus, the adaptive management cycle is a continuous, integrated process that generates information and guides management decisions.

Summary

Ecosystems are far more complex than we can understand. Moreover, extraneous variables such as climate, exotic species, disease, and public opinions are changing constantly and cannot be predicted well. Adaptive management is a model to guide ecosystem managers in dealing with uncertainty; it recognizes that ecosystems are resilient, and that we can adjust our management as we learn more about the ecosystem or as goals change. Adaptive management is an ongoing process that couples social values to ecological knowledge using consensus building and good science.

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Analyzing Forest Landscape Restoration Potential: Pre-settlement and Current Distribution of Oak in the Northwest Wisconsin Pine Barrens

Abstract *Ecosystem restoration and management requires knowledge of the species composition, ecological processes, and structure of natural landscapes. Current forest landscapes of Wisconsin are the result of over a century of human use. Certain ecological processes, such as fire, cannot be studied in the current human-dominated landscape. Our study objective was to reconstruct the historical, large-scale pre-European landscape of the Pine Barrens in northwestern Wisconsin and to compare the extent and abundance of the oak component to its current importance. Our questions were (1) does the current distribution of oak resemble pre-settlement conditions and (2) did oak savannas exist at pre-settlement times, which would indicate a high frequency but low intensity fire disturbance regime. We used a species-level satellite image classification to map the current distribution of oak. The pre-settlement conditions were reconstructed using the U.S. General Land Office (GLO) surveyor notes dating from 1847–59 in a geographical information system (GIS).*

Our results indicate that oak increased in the Pine Barrens landscape over the last 150 years. The increase is particularly strong where nineteenth-century surveyors mentioned oak understory. Fire suppression may have contributed to the oak increase by permitting these understory oaks to reach canopy height. Oak savannas were not widespread in the pre-settlement landscape, but likely did exist in the south-central part of the Pine Barrens, where larger, dispersed bur oaks were noted by the surveyors. Our study demonstrates the value of the GLO data for the broad scale reconstruction of pre-settlement vegetation and disturbance characteristics. These historical data can provide managers with additional information about ecosystems and can assist in restoration management.

Ecosystem restoration and management requires knowledge about the species composition, structure, and processes of the system under consideration. This poses a challenge, because very basic information can be difficult to obtain for current landscapes in Wisconsin due to changes imposed by over a century of land use by European settlers.

Our study focuses on the Pine Barrens region in northwestern Wisconsin (Figure 1). The Wisconsin Department of Natural Resources (DNR) chose this ecoregion as the first in Wisconsin to be assessed as a regional ecosystem. In 1993, the DNR workshop "The Future of Pine Barrens in Northwest Wisconsin" (Borgerding et al. 1995) summarized current understanding of this ecosystem and identified some information gaps regarding the structure and composition of the pre-settlement forest landscapes. For example, the amount of open habitat and forest density present prior to 1840 was a point of discussion. This question is important for ecosystem management of the Pine Barrens; an answer requires study of historic data sources because of ecosystem changes during the last 150 years of European settlement.

The Pine Barrens ecosystem is located on a glacial outwash plain with extremely coarse and nutrient-poor sandy soils. The excessive drainage makes the region prone to drought and frequent forest fires (Curtis 1959). In pre-settlement times, these factors favored tree species such as pine and oak that are adapted to frequent fire. Jack pine *(Pinus banksiana)* has serotinous cones that are

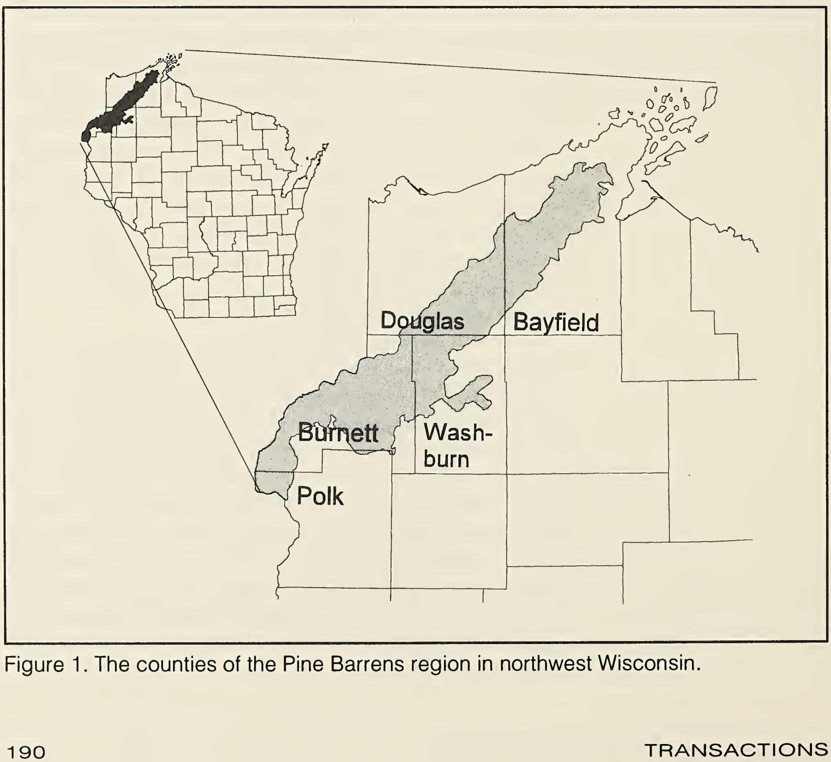

Figure 1. The counties of the Pine Barrens region in northwest Wisconsin.

sealed with resin. High intensity fire melts the resin and opens the cones, releasing the seeds. Regeneration usually follows on the exposed mineral soil. Mature red pine *(P. resinosa),* bur oak *(Quercus macrocarpa),* and to a degree white pine *(P. strobus),* are protected by thick bark from damage by less intense surface fires. Northern pin oak *(Q. ellipsoidalis)* and bur oak are able to resprout if their stems are killed by fire (Curtis 1959).

Very few descriptions exist of the Pine Barrens vegetation before European settlement during the second half of the nineteenth century. Geological surveyors wrote that "in the 'barrens'. . . the trees are either scrub pine *(P. banksiana),* or black-jack oaks *(Q. ellipsoidalis),* averaging in diameter about three or four inches and in height not over fifteen feet. In some places . . . the trees are at considerable distances from each other" (Sweet 1880). Some portion of the Pine Barrens "are covered with scrub pine to the exclusion of all else save underbrush. . . . Other areas are covered with burr, black, and even white oak bushes, with occasional trees of these species" (Strong 1877). Finley, in his analysis of the General Land Office (GLO) surveyor notes, classified the region as "jack pine, scrub (Hill's) oak forests and barrens" (Finley 1951).

All these sources describe forests of low density that contained pine and oak to varying degrees. However, these sources do not provide details about spatial variability of forest composition and structure across the Barrens landscape. Did soil differences affect the pattern of forest structure? Did meso-climatic differences (e.g., the lake effect in the North) result in different forest types? Were the southern parts of the Barrens, being closer to the prairie border, more open?

These questions are highly relevant for ecosystem management, but answering them is difficult. Changes during the last 150 years due to logging, farming, and forestry make it difficult to assess what the pre-settlement ecosystem looked like and how it functioned in relation to past disturbance regimes.

Logging, starting around 1850, focused first on white pine and later red pine (Murphy 1931). Loggers were followed by settlers because the sandy soils were easy to plow (Vogl 1964). Intense forest fires increased due to the slash from the logging operations and also opened the forests. Around 1910, jack pine logging began after technology became available to use jack pine wood for pulping. At this time, the combination of logging and farming probably created more open habitat than ever before. In the 1930s, the economic depression and the depletion of the inherently nutrient-poor and droughty soils caused many farmers to abandon their land. Much tax-delinquent land became the starting point for creating county forests, timber industry holdings, and the Chequamegon National Forest (Vogl 1964). Civilian Conservation Corps workers planted large tracts with jack pine, and the Wisconsin Conservation Department began fire suppression programs. These developments created the present-day forest, which may be much denser than before European settlement.

Our research questions are: what was the relative importance of oak throughout the Pine Barrens, and did oak savannas and woodlands exist in the Pine Barrens before the advent of European settlers? How did the oak component in the landscape change since European settlement?

Savannas are best defined structurally; they have less canopy coverage than forest. Any distinct boundary between savannas and forests is somewhat arbitrary; we follow Curtis (1959), who suggested less than 50% canopy coverage as a threshold to define savanna.

Currently, oak is common in the region, especially in the northern and southern parts. Restoration efforts in the Pine Barrens have focused on open Barrens habitat (Vogl 1964, Vora 1993). Our study investigates whether the existence of oak savannas in pre-settlement times suggests we should discuss their restoration also.

We analyzed the Pine Barrens pre-settlement vegetation using the U.S. General Land Office survey notes in a geographical information system (GIS). We compared these data with the current forest cover as mapped from Landsat satellite imagery. Because the GLO data were not recorded for scientific purposes, they contain some bias. For instance, some surveyors favored certain species over others as witness trees. In some areas, different surveyors mapped the township boundaries (exterior lines) and the township area (interior lines). Nevertheless, the GLO data set is one of the best data sets available for reconstructing pre-settlement vegetation (Galatowitsch 1990, Manies 1997) and for studying pre-settlement vegetation in relationship to soils (Whitney 1982, Delcourt and Delcourt 1996), fire (Lorimer 1977, Kline and Cottam 1979, Grimm 1984), and windthrow (Canham 1984). A number of studies used GLO data to examine landscape changes (Stearns 1949, Mladenoff and Howell 1980, Iverson and Risser 1987, Iverson 1988, White and Mladenoff 1994, Whitney 1994). Studies that analyzed the GLO data on an individual witness tree level usually examined areas no larger than a few townships (Thomson and Fassett 1945, Delcourt and Delcourt 1996). For some Midwestern states, generalized maps of the pre-settlement vegetation have been generated (Finley 1951). However, these maps required a classification of the witness tree data into general cover classes, thus losing much detail.

Methods

GLO Data analysis

Wisconsin was initially surveyed around the middle of the nineteenth century. The land was divided into townships (6 x 6 miles), sections (1 x 1 mile), and quarter-sections (0.5 x 0.5 mile) so that it could be sold to homesteaders and logging companies. To establish the location of each township, section, and quarter-section, survey posts were placed at each corner (all referred to as corners in the following). The surveyors marked 2–4 witness trees in the vicinity of each corner. In their journals, the surveyors recorded the species, diameter, and distance from the corner for each tree. Sometimes, they also described understory vegetation.

Our study is one of the first to analyze GLO witness tree data in a GIS for a large ecoregion. The advantage of the GIS-based approach is that a high level of detail can be maintained for extensive areas. The data set is part of a larger database of the entire state of Wisconsin currently under development at the Department of Forest Ecology and Management at the University of Wisconsin-Madison in cooperation with the Wisconsin DNR (Manies 1997). For our analysis, we used only the witness trees at township, section, and quarter corners and disregarded trees along section lines and at so-called meander corners, where survey lines intersected water bodies. The data set contains point information for 5,086 corners with a total of 11,153 trees in the Pine Barrens. For each corner, we calculated the mean distance traveled from the corner to record the witness trees. We did not interpolate between the corners to derive forest type polygons, but rather analyzed the complete data set.

Satellite image analysis

To compare the GLO data with the current vegetation cover, we utilized a species-level satellite image classification previously derived for northwest Wisconsin (Wolter et al. 1995). A number of studies have used satellite imagery to map forest cover (Hopkins et al. 1988, Moore and Bauer 1990, Hall et al. 1991, Bolstad and Lillesand 1992, Woodcock et al. 1994). Image processing software uses reflectance differences between tree species to classify raw satellite data into land cover maps (Lillesand and Kiefer 1994). The distinction of deciduous from coniferous forest usually can be achieved with an accuracy greater than 85%. However, differentiating among deciduous species is difficult and less accurate when only a single satellite image is used. For instance, the reflectance of sugar maple *(Acer saccharum),* trembling aspen *(Populus tremuloides),* and red oak *(Q. rubra)* are not different during the peak of the growing season. Single-species classification accuracy can be improved by analyzing a suite of images throughout the time of senescence and leaf flushing (Wolter et al. 1995). Peak fall colors for red oak are about two weeks later than for sugar maple. In spring, trembling aspen leafs out about one week earlier than other hardwoods. Satellite imagery captured at these different points can identify the distribution of various species. Using a total of five satellite images, Wolter et al. (1995) were able to classify nineteen types of forest cover and eight other land cover types with an overall accuracy of 83.2%.

In the satellite image classification, red oak occurs predominantly in the northern half and pin oak in the southern half of the Pine Barrens (Plate 2b; see p. 201). For red oak, the producer's accuracy of the classification was 86.7% and for pin oak 81.6%. Producer's accuracy indicates what percentage of the pixels on the ground was correctly identified in the classification. The user's accuracy was 84.8% for red oak and 100% for pin oak. User's accuracy indicates what percentage of the pixels in the classification is actually that species on the ground. For example, all pin oak on the map is pin oak on the ground, but 18.4% (100%–81.6%) of all pin oak on the ground was mapped as other classes in the image classification. The satellite image classification does not identify bur oak because there were not enough pure stands of this species to use as references for the classification algorithm (Wolter et al. 1995).

Data integration

Examining landscape changes by comparing GLO data to a satellite image classification is not straightforward. The two data sets have very different data capture methods and spatial resolutions. The GLO surveyors mapped points at 0.5 mile distances. They sampled between one and four trees, commonly two, in the vicinity of the corner. The species chosen were not necessarily the dominant canopy species. In contrast to the GLO data, the satellite image classification contains a continuous grid with a 28.5 x 28.5 m pixel size. Each pixel is classified according to its dominant canopy species, thus containing only one tree species.

Processing was required before the two data sets could be compared. Each GLO corner location falls within a single pixel of the satellite image classification. However, the surveyors chose witness trees from a larger radius than 14.25 m, which is half of a pixel (28.5 m). Therefore, we recorded presence or absence of oak in the satellite classification in circles, or buffers, around each corner. This operation was performed three times with different buffers (5, 9, and 21 pixel) to evaluate the effect of different buffer sizes on our analysis (Figure 2). We re-classified the GLO data to represent the presence or absence of oak at each corner, thereby making the two data sets compatible. In the integration of GLO data and the current classification, each corner was classified as either (1) oak present only in the GLO data, (2) oak present only in the satellite image classification, (3) oak present in both data sets, or (4) oak not occurring.

For a general comparison of data sets, we calculated the relative occurrence of oak in comparison to other tree species in the GLO data set and the satellite image classification of single pixels. In the GLO data we summarized how often the surveyors found each tree species and calculated percentages for each species. The calculation of relative occurrence of tree species in the satellite image classification was based only on forest classes because classes such as water or settlements were not recorded in the GLO data, but classified in the satellite image. The comparison of relative occurrences is independent of buffer sizes.

Results

GLO data

The distribution of pre-settlement forest vegetation derived from the GLO data suggests that the Pine Barrens was not a homogenous region (Plate 1a; see p. 200). The northern part in the Bayfield Peninsula was dominated by red pine, intermixed with white pine, red oak, and jack pine.

The central part of the Barrens in Douglas County was covered predominantly by jack pine. Red pine occurred largely along the edges of the outwash plain or in the vicinity of natural firebreaks such as lakes. The central part also contained a 5-km long patch where no trees were recorded by the surveyors. Their field notes mention that charred sticks were used as corner posts in this patch, indicating a recent fire.

The southern part of the Barrens, in western Burnett and in Washburn Counties, was characterized by a north-south gradient, with jack pine dominating in the north and red pine, oak, and white pine dominating the south. Pin oak and bur oak often occurred

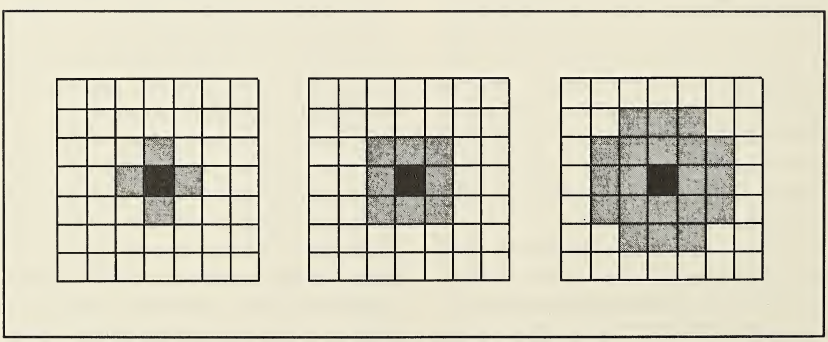

Figure 2. Different buffer sizes used to estimate oak presence around corners in the satellite image classification.

close to lakes, which are particularly abundant in this area (Plate 1b).

The extreme southwestern part of the Barrens, in southwest Burnett and northwest Polk Counties, showed a similar north-south gradient, though the surveyor of the townships in Polk County (H. Maddin) did not distinguish among pine species. Bur oak was the most common oak, occurring along the valley of the St. Croix River and the edge of the outwash plain. Corners where no trees could be found were located in marshy areas.

Oak diameters in the GLO data were not randomly distributed across the Barrens (Plate 1c). In the north and central Barrens, most of the oaks were small (10–30 cm diameter), with some trees as large as 50 cm. The largest oaks, up to 85 cm in diameter, were recorded in the southern and southwestern parts, usually in close vicinity to lakes and streams.

A characteristic of savannas is their low tree density. Large distances between a corner and its witness trees in the GLO data indicate low relative tree density (Plate 2a). The largest distance class (251–2000 m) represents corners where surveyors found very few trees due to recent fires or marshes. The distribution of these points follows no clear pattern except in one patch in the central Barrens mentioned above. The corners in the smaller distance classes (<25–250 m) demonstrate a strong northeast-southwest gradient of the forest densities. Forest density was highest in the northeast and much lower in the southwest of the Pine Barrens.

Comparison of GLO and satellite data

The abundance of oak region-wide increased between pre-settlement times and today. The apparent amount of increase is partly dependent on the buffer size used for detecting oak in the satellite image classification.

Table 1. Number of corners where oak was present or absent in 1850 and 1987 depending on the buffer size used for detecting oak by satellite classification.

	Buffer size (# of Pixel)		
	21	*9*	*5*
Oak only in 1850	226	304	343
Oak only in 1987	1,539	1,050	819
Oak in 1850 and 1987	259	181	143
Never oak	3,057	3,548	3,779

Larger buffers will always result in a greater increase (Greig-Smith 1983). However, even with the most conservative five-pixel buffer, the oak increased from 1850 to 1987 by 198% (9 pixel: 253%; 21 pixel: 371%).

The absolute number of corners where oaks occurred only in 1987 increased by 720 (48%) when the buffer size is increased from 5 to 21 pixels (Table 1) and conversely, the number of corners without oak decreased by 722 (19%). For corners with oaks in the GLO data, 53% also had oak in the satellite image classification when calculating a buffer of 21 pixel, but only 29% when a buffer of 5 pixels was used.

Many changes in oak occurrence are rather local (Plate 2c). We present only the increase estimated with the largest buffer size; maps from the two smaller buffer sizes reveal the same areas of oak increase. Especially in the south, there are many cases where a given corner contained oak only in the GLO data and the neighboring corner had oak only in the satellite image data. These changes are most likely due to local patch dynamics.

In the north, there are fewer corners where oak occurred only at pre-settlement times, and many of the corners contained oak in both data sets. There is also a strong increase in oak throughout Bayfield County. The central part of the Barrens experienced the smallest increase of oak (Figure 3). The areas where

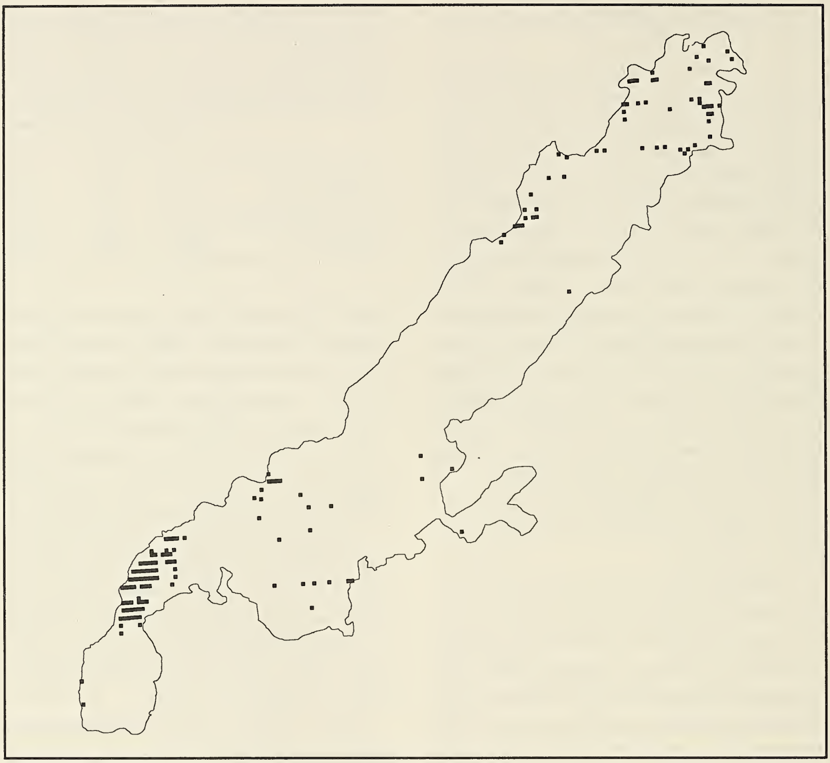

Figure 3. Corners with oak understory in the GLO data.

oak was mentioned in the understory from GLO surveys are the same areas where a strong increase of oak occurred by 1987.

The relative occurrence of oak versus other cover types as represented in GLO data and the satellite image classification of the Pine Barrens region as a whole agreed with the results obtained with the buffer analysis (Figure 4). Out of the total area covered by forest, oak and pine combined occupied about 62%. However, oak alone increased from 8 to 23%, and pine decreased correspondingly.

Discussion

Ecosystems are dynamic entities, and studying them at only one point in time (e.g., the GLO survey date) provides an incomplete picture. Disturbance events, like large crown fires, alter the environment drastically over short time periods. A study that analyzes only data taken before the fire is likely to underestimate the influence of fire, while a study based on data captured after the fire might carry the opposite bias.

Furthermore, ecosystems adapt to long-term

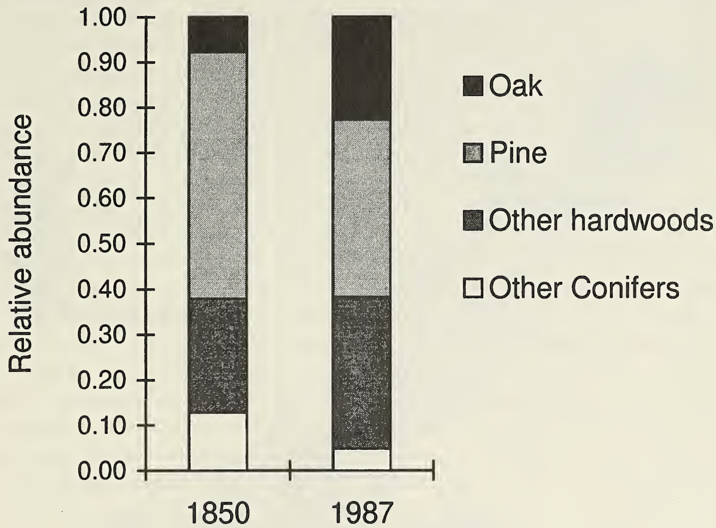

Figure 4. Relative amounts of tree species groups in the forests of the Pine Barrens ecoregion as calculated from GLO data and satellite image classification.

environmental changes. Climate has changed throughout the Holocene, and with it, vegetation cover has changed (Davis 1986, 1993, Webb et al. 1993). Predicting how the vegetation would have changed since 1850 in the absence of European settlement is problematic.

The pre-European settlement vegetation was not entirely natural or free of human alterations. Native Americans deliberately burned parts of the landscape to increase berry production and hunting opportunities (Murphy 1931), but the magnitude of ecosytem changes by Native Americans is difficult to assess, particularly in northern forest regions (Lewis and Ferguson 1988, Clark and Royall 1996).

The GLO data are not equivalent to the potential natural vegetation. When analyzing the pre-settlement vegetation, these limitations have to be kept in mind. We do not consider the vegetation cover suggested by the GLO data as a necessary goal for resource managers, nor do we advocate restoration of the landscape to a specific point in time. However, the pre-settlement vegetation cover was certainly less altered by humans than the current forest cover. Analyzing the pre-settlement vegetation provides a unique opportunity to study ecosystem composition, structure, processes and variability in relatively more natural conditions. Presettlement vegetation data are highly relevant where ecosystem management is being attempted, because they provide evidence of vegetation patterns at another point in time and under different disturbance regimes.

The importance of surveyor bias contained in the GLO data has been discussed in various publications (Bourdo 1956, Delcourt and Delcourt 1974, Grimm 1984, Iverson and Risser 1987). Opinions range from "the information recorded by the surveyors provides an unbiased sample of vegetation cover as it existed in presettlement days" (Vogl 1964, p. 161) to much more conservative analyses of surveyor bias and attempts to quantify it (Bourdo 1956, Delcourt and Delcourt 1974, Manies 1997). The species recorded at a given location may have been a singular occurrence. Also, absence of a tree species does not necessarily indicate that the species was absent from the landscape. The ability of surveyors to identify tree species correctly is variable. In Polk County, in the southern Barrens, the surveyor (H. Maddin) recorded only 'pine' without further distinction. The occurrence of black oak *(Quercus velutina)* in the Pine Barrens is very unlikely, because its northern range does not reach this region. However, several surveyors recorded black oak (Plate 1b), probably referring to the black oak group that contains northern pin oak, northern red oak, and black oak (Curtis 1959). The raw information of the surveyor notes needs to be interpreted carefully before ecological conclusions can be drawn.

The scale of the GLO data limits its minimum mapping resolution (Delcourt and Delcourt 1996). This makes analysis of small areas, such as single townships, questionable. However, the resolution of the GLO data appeared to be adequate to interpret regional trends at the scale of the Pine Barrens landscape (450,000 ha). Regional trends can be concealed when data are classified and aggregated before the analysis. The use of a GIS allowed us to handle the large amount of detailed information, without classifying it initially. This was essential for our approach to compare species occurrence at each section corner.

Despite potential problems, the GLO data contain a vegetation sample of tremendous value. The data were collected during a relative short time period. The survey of the Pine Barrens was completed in twelve years (1847–1858), and 68% of the data were collected in two years (1855–1856). During these few years the Pine Barrens landscape presumably did not experience major changes. The brief survey period of the Barrens ensures that spatial vegetational differences reflect environmental gradients and not temporal changes.

The data collection was standardized, and single surveyors covered large areas. For instance, three surveyors (H.C. Fellows, E. Sears, and A.C. Stuntz) surveyed 74% of all corners in the Pine Barrens. The small number of surveyors minimizes the impact of personal bias.

The sampling scale of the GLO survey is uniform, which makes regional comparisons possible. There are no other detailed presettlement vegetation data available for large regions. The value of the GLO data for vegetation analysis, despite all constraints, becomes apparent when examining the species composition of the Pine Barrens (Plate 1a). The occurrence of red pine and oak throughout the Barrens is associated with soil, topographic, and hydrologic features that influenced fire patterns. Slight differences in soil quality, topography, and hydrology are reflected in the GLO data. Detailed soil maps for the Pine Barrens are not available, but the mapping of Landtype Associations by the Wisconsin DNR provides a coarse picture of soil productivity (Figure 5). On the poorest soils, jack pine forms pure stands. Slightly more productive soils carried mixtures of red and white pine. The best soils in the Pine

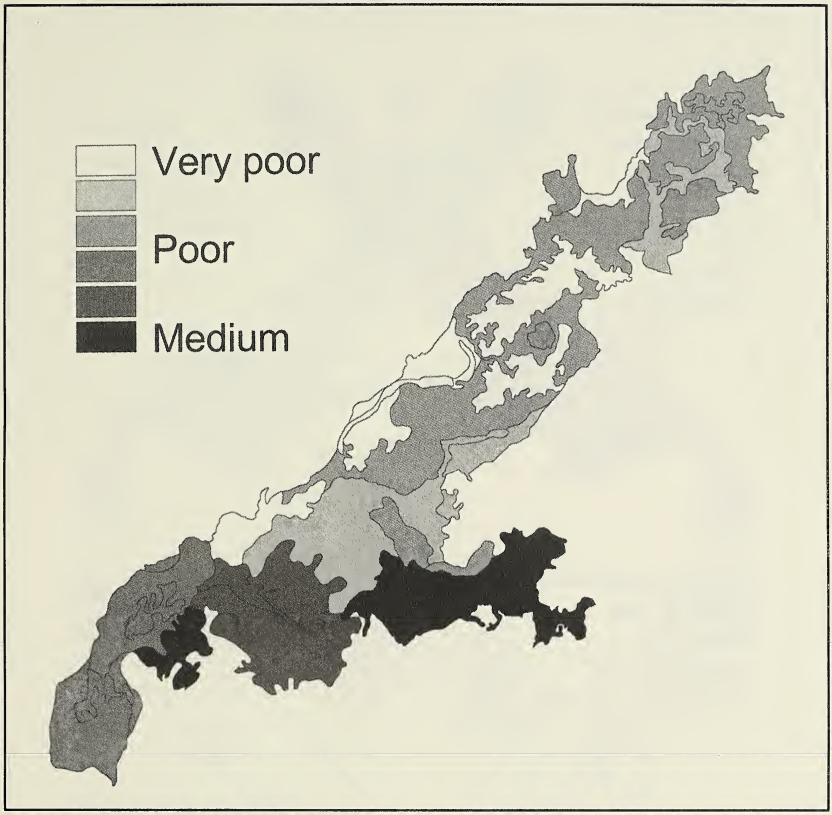

Figure 5. Soils of the Pine Barrens ranked according to their soil productivity (Wisconsin Department of Natural Resources).

Barrens supported oaks. The forests in the northwestern Pine Barrens are dominated by red pine, despite the poor soils. The higher precipitation, lower summer temperature, and lower evapotransporation due to the lake effect might have limited fire in this area. Furthermore, the rolling topography of the Bayfield Peninsula provided microhabitats where trees other than jack pine found favorable growing conditions.

Stand densities reveal a strong gradient, generally being lower in areas closer to the forest-prairie border region (Plate 2a). The recorded values in the southern Pine Barrens, which are often between 25 and 250 m, indicate landscapes of open forest and solitary trees. For comparison, in mesic hardwoods the average distance between corners and witness trees is about 11.6 m (K. Manies, unpublished data).

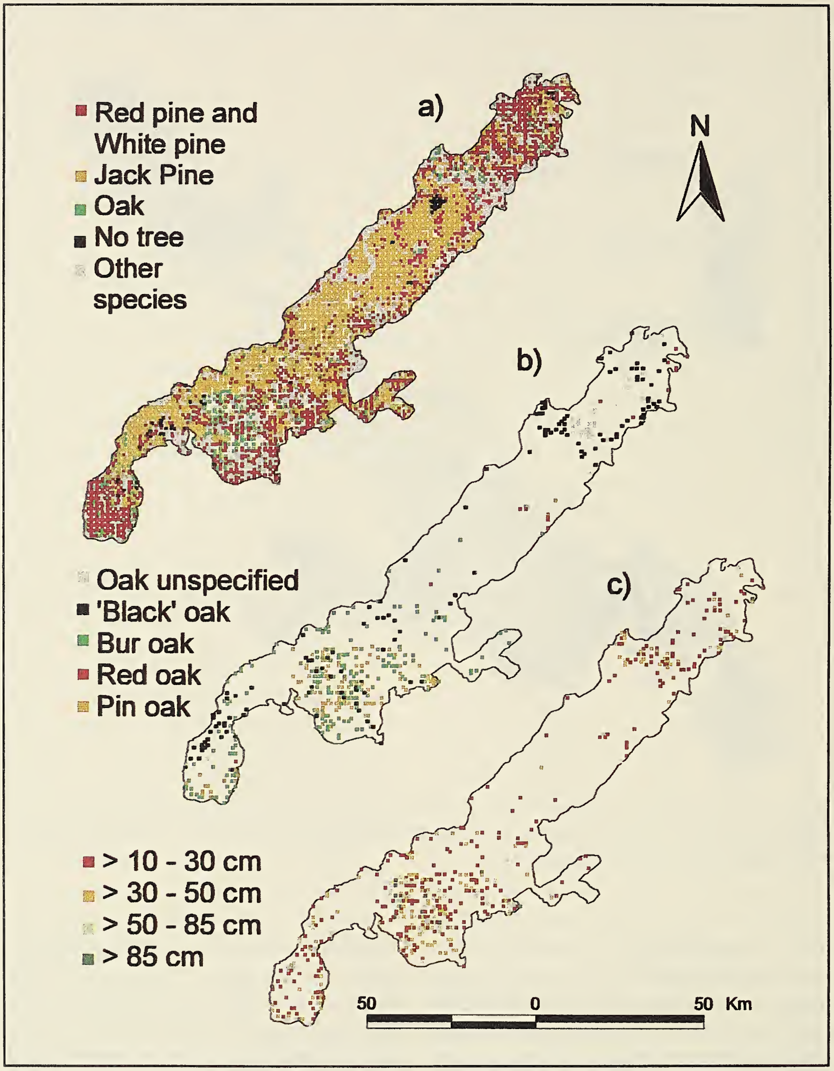

Plate 1. (a) Dominant tree species in the GLO data, (b) oak species distribution in the GLO data; (c) average diameter of oak in the GLO data.

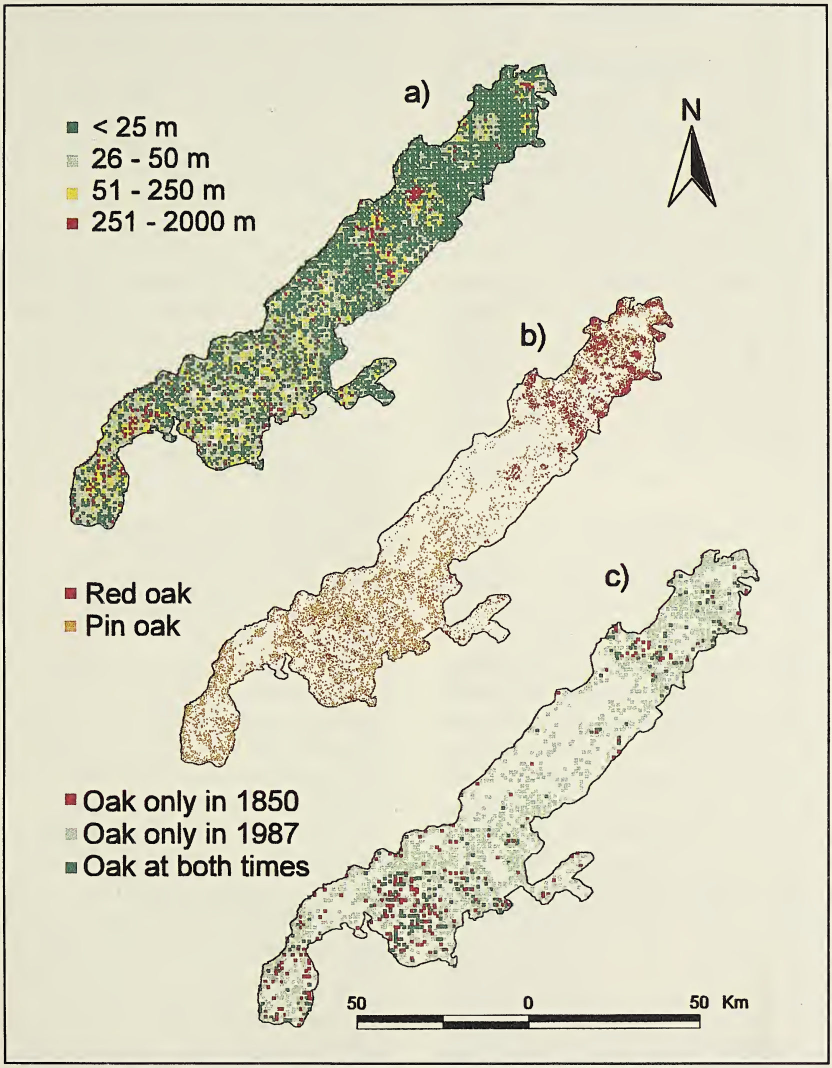

Plate 2. (a) Average distance between witness trees and corners; (b) oak occurrence in the species level satellite image classification; (c) changes in the oak distribution from pre-settlement to today when examining the satellite image classification with a 21 pixel buffer (compare Figure 2).

Conclusions

Our GLO data analysis suggests that oak savannas were not widespread, but possibly existed as localized patches in the southern and southwestern Pine Barrens. In these regions, soil quality, stand densities, the presence of bur oak, and the relatively large tree diameters in the GLO data match the characteristics of oak savannas.

The increase of oak from pre-settlement times to today was detectable with different methods, and increases were particularly strong in areas where the GLO data contained oak as an understory species. This increase of oak is probably related to pine logging and fire suppression, which allowed oak sprouts to grow until they became part of the canopy.

What are the implications of our results for ecosystem management of the Pine Barrens? First, the Pine Barrens were not uniform in terms of oak occurrence. The surveyors mentioned red oak only in the northeastern Barrens. Pin oak was mostly recorded in the south-central Barrens and bur oak in the southwestern part of the Barrens. The poorest soils in the central Barrens probably did not contain much oak in pre-settlement times. This general distribution of oak species still occurs in the current landscape, but oak has increased overall.

The strong northeast-southwest density gradient at pre-settlement times (Plate 2a), when forests were more open in the southwest and denser in the northeast, diminished as forest came under management and fires were suppressed. Landscapes in the central part of the Pine Barrens were probably shaped by high intensity crown fires with return intervals of less than 50 years (Givnish 1995). Jack pine dominated this area as the fires and droughts prevented other species from dominating. If restoration of the pre-settlement conditions is attempted in this area, management should focus on large patches of open habitat that can resemble openings of fire origin. These open patches might shift in the landscape, and their features could be partially achieved by clear-cutting (Niemuth 1995). Upon the creation of a new, large open patch, a previous patch could be regenerated with jack pine. This management could mimic typical jack pine regeneration after fire for some habitat purposes. However, all processes typical of the fire-controlled landscape would not be duplicated with only logging. Areas of low tree density and substantial open areas (mean tree-corner distance of 0.25 – 2 km) also occurred within the jack pine-dominated central Barrens, on the poorest soils.

The northern Barrens in Bayfield County contained more diverse forests with a species mix of jack pine, red pine, white pine, and red oak. These mixed forests were relatively dense. The ecosystem in this area would probably benefit from forest management that maintains all species in the landscape. Large-scale disturbances were much less common in this area, but smaller, intense disturbance patches can be assumed due to the complete lack of trees at some corners.

In the southern and the southwestern Barrens, extensive crown fires were probably rare due to a higher density of lakes that functioned as fire breaks. In this region, red pine, white pine, and oak were interspersed with jack pine, but fires with lower intensity, although perhaps higher frequency, allowed oaks to reach diameters of 50 cm and more. The average distance between witness trees and the surveyed corner was often more than 50 m. This is the region where we assume local oak savannas occurred. Given that fire is a stochastic process, locations of oak savanna were not stationary. One area with repeated low intensity fires might have become a savanna. Another area, after no fires for several decades, might have experienced a crown fire exposing mineral soil and creating conditions favorable to dense jack pine regeneration.

Ecosystem management and landscape restoration needs to take such natural variation into account, aiming for a constantly changing and heterogeneous mosaic at broad scales. Ideally, conservation efforts and restoration attempts should not focus on single sites but rather on the landscape as a whole, permitting all stages of natural vegetation types to exist. Such efforts need to be coordinated among landowners to be feasible at large scales, which can be difficult. However, it offers a chance to manage forests and to generate revenues while preserving ecosystem characteristics and varied habitat values. For example, during the harvest of a jack pine stand with an oak component, a resource manager may leave sparse cover of oaks and use prescribed burning in subsequent years to prevent jack pine regeneration. This stand could be maintained as an oak savanna for a few decades before the oak is removed and jack pine is seeded again. Such a savanna would not be identical to a pre-settlement savanna; its origin does not resemble a natural process. However, such management alternative may provide habitat as well as revenues in areas where large-scale prescribed burns are difficult.

We do not understand the Pine Barrens ecosystem enough to explain fully the influence of species composition and structure on long-term sustainability. However, our analysis helps us to know the general structure and species composition of the Pine Barrens at pre-settlement times even without a full understanding of the ecosystem's complexity. These conditions were the result of an evolution of the Pine Barrens over thousands of years. When we think about the future of the Pine Barrens, the past can contribute useful guidelines.

Acknowledgments

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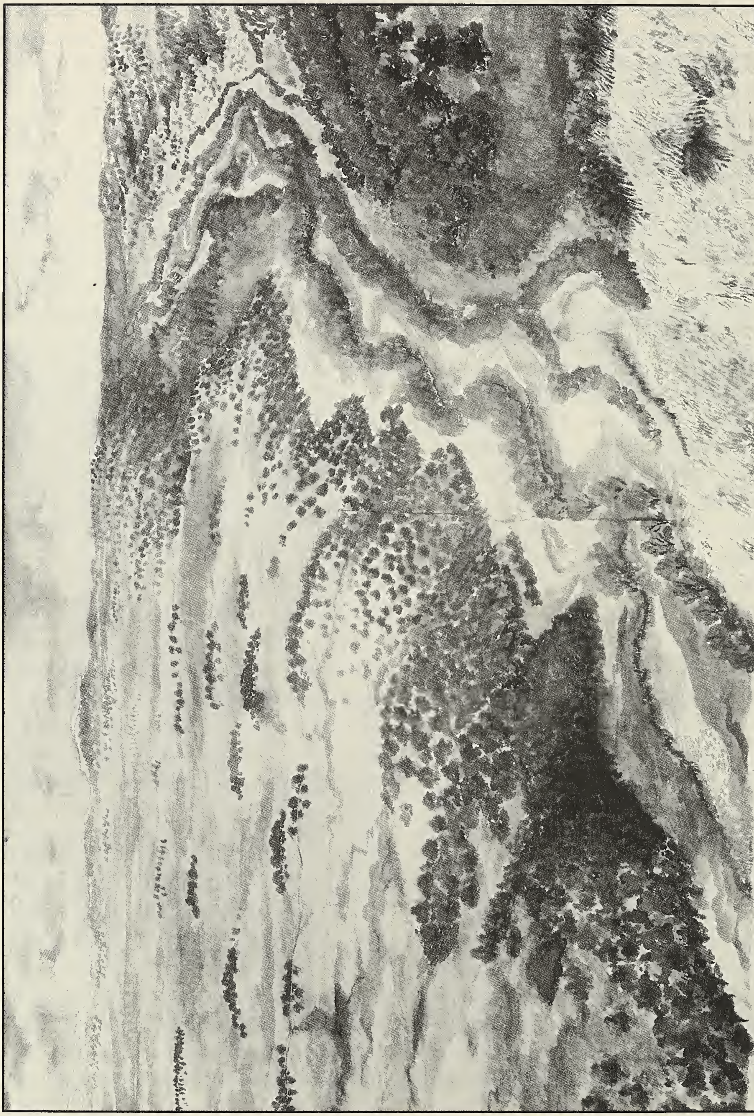

Plate 1. A reconstructed depiction of a landscape scene in the oak savanna-woodland ecotone prior to development by European settlers (courtesy of The Nature Conservancy).

Stanley A. Temple

Surviving Where Ecosystems Meet: Ecotonal Animal Communities of Midwestern Oak Savannas and Woodlands

Abstract *The animal communities associated with Midwestern oak savannas and woodlands have a typical ecotonal character. They are relatively rich in species, but they are composed mostly of species that have the centers of their geographic ranges in either the deciduous forest biome to the east or the prairie biome to the west. Few species have ranges centered on the transition zone (or ecotone) between these major biomes. Within the ecotone, species show individualistic patterns of habitat selection, with most species associated with a particular habitat type within the ecotone's complex mosaic of patches, ranging from prairies, through savannas and woodlands, to forests. The characteristics of the landscape surrounding a remnant patch of oak savanna or woodland (its context) influence the composition of the animal community in the patch, in some cases even more strongly than the characteristics of the patch itself. At a large biogeographical scale, most species in the ecotone are near the edges of their ranges, and it is likely that their fitness is lower than it is nearer the centers of their ranges. At a smaller landscape scale, the patchy mosaic of habitats in the ecotone produces ecological phenomena, such as edge effects, that can reduce fitness of some species. Populations of species near the edges of their ranges or in relatively small habitat patches are often sink populations that require subsidies of dispersing immigrants from source populations either nearer the center of the range or in larger patches of forest or prairie habitat to remain viable. The remnant patches of oak savanna and woodland in the Midwest are now small, degraded, isolated and out of context. Scale and context (both regional and local) are, therefore, important predictors of the composition and viability of animal communities in these remnant patches. Current efforts to manage and restore remnant oak savannas and woodlands must address these needs of the animal community if they are to truly reproduce the characteristic diversity of species associated with the ecotone.*

The debate over whether Midwestern oak savannas and woodlands are a biome (a discrete regional ecosystem) or an ecotone (a transitional zone between the deciduous forest biome to the east and prairie biome to the west) has so far focused almost exclusively on characteristics of the associated plant communities (e.g., Curtis 1959 versus Packard 1988), but the outcome also has important implications for animal communities and biodiversity conservation efforts. The following quote from the "Midwestern Oak Savanna and Woodland Recovery Plan" highlights the debate: "[This] controversy may be the single most important scientific issue that must be resolved if we are to recognize and preserve oak savannas—or, as a practical matter, reconstruct them. . . ." (Fralish et al. 1994). The distinction between a biome and an ecotone is more than ecological semantics. It influences strategies for preservation and restoration, and it may affect animals more than plants. In the case of Midwestern oak savannas and woodlands, I will show that the animal communities associated with these ecological systems have typical ecotonal characteristics and, therefore, present special challenges for conservationists.

Ecologists have recently focused renewed attention on phenomena associated with the transition zones between adjacent ecological systems (di Castri et al. 1988). Whether they are continental-scale transitions between biomes or landscape-scale transitions between different vegetation patches in a mosaic, these ecotonal situations are usually associated with dynamic gradients in the physical environment (Gosz 1993). Across these environmental gradients there are parallel gradients in the structure and composition of the biotic community (Risser 1993). These biotic changes are in part related to the fact that many organisms reach distributional limits in or near transition zones (Hansen and di Castri 1992). In biome ecotones many species typical of the communities in the adjacent biomes reach the peripheries of their geographic ranges, and in patch ecotones many species reach edges of their home ranges where habitats change (Gosz 1993).

In contrast, within a biome or within a vegetation patch, environmental and species-compositional gradients are not as steep, and the composition of the biotic community tends to be relatively homogeneous. To some extent, it is the homogenous character of within-biome and within-patch communities that defines these ecological systems. In contrast, it is the relatively rapid changes in community composition that occur across ecotones that define them (Risser 1993).

Ecotones are often inhabited by an unusually rich-but-delicate diversity of species (Hansen and di Castri 1992). Transition zones between ecological systems often possess some biotic and environmental characteristics of both adjacent systems, as well as a few characteristics that are unique to the ecotone. The overlap of these normally segregated elements contributes to the biological richness of ecotones. In the case of biome ecotones, some species whose geographic ranges are centered on adjacent biomes, as well as a few species endemic or nearly endemic to the zone of transition, are found together in the ecotone (Gosz 1993). In the case of patch ecotones, species from adjacent habitat patches, as well as "edge species" that preferentially occupy the interface, have home ranges that overlap in the transition zone (Gosz 1993).

The maintenance of this unusual assemblage of species within an ecotone often depends on the proximity of adjacent biomes or patches that support demographically healthy populations. Without these "source populations" near the core of their range or habitat, peripheral "sink populations" near the edges of their range or habitat may be unable to maintain themselves intrinsically (Fahrig and Merriam 1985, Temple and Cary 1988, Hansen and Urban 1992). For those species populations at the edges of their ranges or habitat, persistence may depend on subsidies of dispersing individuals that immigrate from source areas (McCullough 1996, Wiens 1996,). Without these subsidies, marginal sink populations have difficulties persisting in an ecotone. This reduction in fitness near the edge of the range or habitat is one of the fundamental premises of biogeography (Brown and Gibson 1983, Cox and Moore 1993).

These patterns associated with ecotones have important implications for conservation and restoration of ecotonal communities (Holland et al. 1991; Risser, in press). Because many species will be at the limits of their distribution in a biome ecotone, they may be marginal in terms of demographic viability. Already coping with less than ideal conditions in marginal environments, they are especially vulnerable to the types of environmental swings (Figure 1) that often characterize ecotones (Gosz and Sharpe 1989).

Within the Midwestern oak savanna-woodland ecotone, a good example of such a variable environmental feature is precipitation (an important ecological factor in the

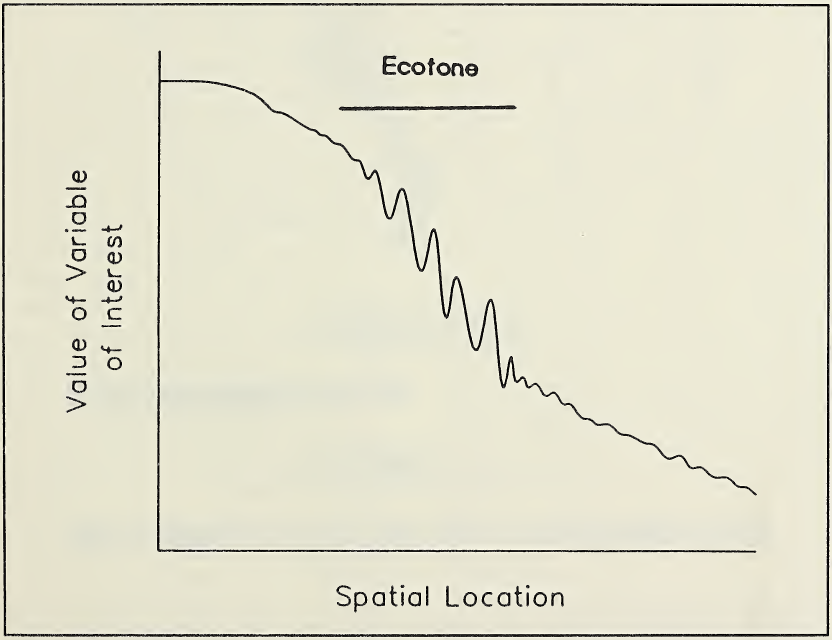

Figure 1. General trends in environmental conditions within biomes and across the ecotone that separates them.

oak savanna-woodland region), which is more variable year to year in the ecotone than it is in either the prairies to the west or the forests to the east. This pattern is confirmed by a continent-wide analysis of coefficients of variation in annual precipitation during June, July, and August, 1979–1996. Within the Midwestern oak savanna-woodland ecotone (as mapped in Figure 2), coefficients of variation for 2.5-degree blocks were in the range of 0.3–0.5, whereas they were in the range of 0.1–0.3 over both the eastern deciduous forest and the tallgrass prairie regions (J. Foley, personal communication).

Preserving sink populations as members of the ecotonal community can be very challenging. Persistence of marginal populations in a biome ecotone may depend crucially on immigration from source populations nearer the centers of species' ranges in adjacent biomes. If those source populations are not

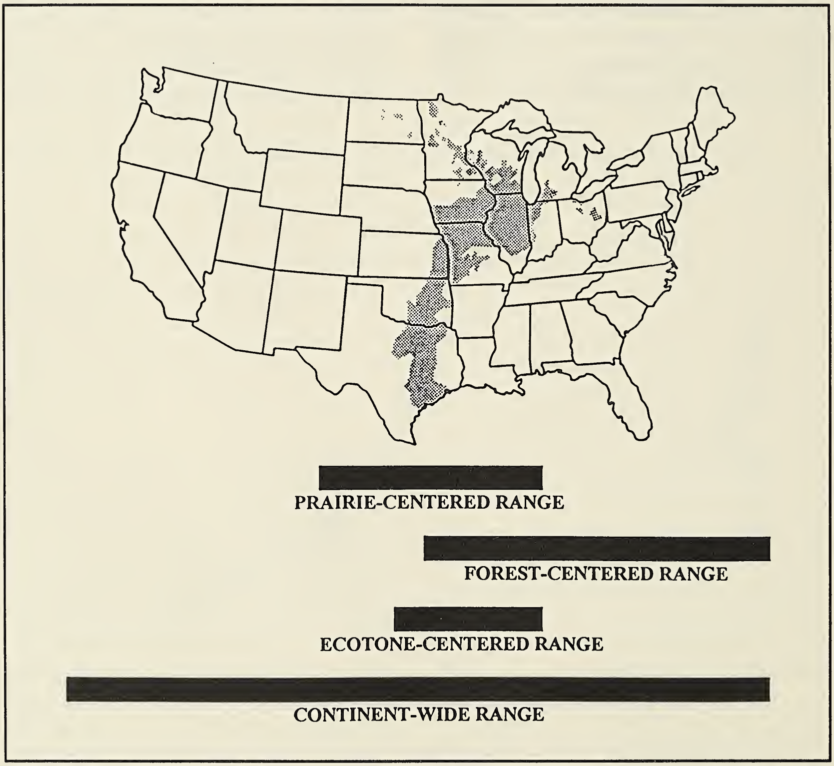

Figure 2. Overlapping geographic ranges of four groups of species found in the Midwestern oak savanna-woodland ecotone (which is indicated by the stippled area of the map).

thriving, centrifugal dispersal movements may be inadequate to maintain peripheral populations in the ecotone. As a result, the presence and persistence of a species in a biome ecotone may depend as much, or more, on conditions in adjacent biomes than on conditions in the ecotone itself (Wiens et al. 1985). As an example, the Dickcissel *(Spiza americana)* has its geographic range centered on the tallgrass prairie biome, but its range extends into the Midwestern oak savanna-woodland ecotone. Basili et al. (1998) have shown that populations near the center of the range have better reproduction and population stability than the peripheral populations in the upper Midwest.

Parallel patterns exist at the landscape-scale in ecotonal patches (Holland et al. 1991). The richness of species and the composition of the community in a patch ecotone depends importantly on the characteristics of the species pools in adjacent habitat patches (Temple et al. 1979). The size of a habitat patch can be a powerful predictor of the types and number of habitat specialists found in it (Harris 1984, Shafer 1990). An ecotone between two small patches should, therefore, have fewer species than an ecotone between larger patches. Furthermore, in a landscape in which one patch type dominates, the composition of the community in patch ecotones can be expected to be heavily biased towards the species from the dominant patch type.

The viability of populations of habitat specialists within a habitat patch may depend on the size of the patch and its proximity to other patches of the same habitat. A landscape composed of a mosaic of small, isolated habitat patches and their associated patch ecotones should support few source populations of habitat specialists. In such a landscape, many habitat specialists may be represented by sink populations incapable of producing a surplus of individuals that leave prime habitat in the core of patches and settle into marginal habitat in ecotones between patches.

Midwestern Savannas and Woodlands as Biome Ecotones

If the Midwestern oak savannas and woodlands represent a biome, there should be characteristic animal species with geographic ranges centered on the region. Alternatively, if they represent a biome ecotone between forests and prairies, there should be few species with ranges centered on the region and many with ranges centered on adjacent biomes. I examined the biogeographic affinities of 186 vertebrates (all species of amphibians, reptiles, birds, and mammals) and 224 invertebrates (a subset of well-studied Lepidoptera and Orthoptera) that are found in the region that has been described as oak savanna and woodland (Nuzzo 1986). The lists were prepared by the Midwest Regional Office of The Nature Conservancy based on the distributional data in the Natural Heritage Inventories for the 10 states (MN, WI, MI, IL, IA, IN, MO, NB, OK, TX) that contain examples of the ecotone. Inspection of a variety of range maps for these well-studied animal species (e.g., Opler et al. 1995, Sauer et al. 1996) allowed me to assign them to four groups: those with broad transcontinental ranges and those with the geometric centers of their ranges located in either the prairie biome, the deciduous forest biome, or the oak savanna-woodland region (Figure 2). The results are shown in Table 1, which reveals a clear pattern. Only 0.4% of these animals have geographic ranges centered on the oak savanna-woodland region. The largest component (50% of the sample animal species in the oak savanna-woodland

Table 1. Biogeographic affinities of 410 animal species found within the oak savanna-woodland region of the Midwest. The four distributional categories are illustrated in Figure 1.

Taxa	Number of Species Examined	Percentage of Species Having Affinity With: Continental	Forest	Prairie	Ecotone
Vertebrates	186	34	48	15	3
Invertebrates	224	8	52	36	4

region) has biogeographic affinities with the deciduous forest biome. These 410 species are obviously just a sample of the fauna of the region, but distributional data are not readily available for other groups of lesser-known animals. The pattern, though based on a biased sample, is so compelling that it is difficult to believe it is merely an artifact of the taxa examined.

Many of the species found in the oak savanna-woodland region reach the limits of their geographic ranges there or nearby. Even allowing for the possibility that some species endemic to the oak savanna-woodland region may have been extirpated before modern biogeographers documented their ranges, the distributions patterns are consistent with the conclusion that animals of the oak savanna-woodland region form a typical ecotonal community.

Within a biome, the spatial diversity of vegetation patches is relatively low, but within a biome ecotone the diversity of patches is higher (Figure 3). Although we have few depictions of the landscape of the original oak savanna-woodland region, the eye-witness accounts and reconstructions based on them (Leach and Ross 1995) paint a picture of a landscape composed of a patchy mosaic of prairie, savanna, woodland and forest (e.g., Packard and Mutel 1997; see Plate 1). This landscape pattern is consistent with the oak savanna-woodland region being a biome ecotone rather than a biome.

Animal Communities of Midwestern Ecotonal Patches

At the landscape scale, the oak savanna-woodland ecotone is composed of a mosaic of patches of vegetation (typically tens to thousands of hectares in size), ranging from open prairie grasslands through closed-canopy forests (Figure 4). If one assumes that patches with less than 10% woody cover are true prairie and patches with more than 65% woody cover are true deciduous forest, the remaining areas with 10–65% woody cover can be considered ecotonal patches (see Leach and Ross 1995 for a discussion of these criteria). These three landscape elements form complex mosaics across the oak savanna-woodland region of the Midwest.

Animal species in the region show individualistic patterns of habitat selection within this mosaic (Herkert 1994, Swengel 1994, Panzer et al. 1995). The animal communities within patches of either prairie or forest tend to be composed of typical habitat specialists, but the composition of the communities in ecotonal oak savannas and woodlands tends to be a much more variable mix of species, reflecting both the vegetation structure of the patch ecotone and the surrounding landscape.

This variability can be seen in the composition of the bird communities in 4 patches of prairie, 14 patches of oak savanna-woodland, and 8 patches of

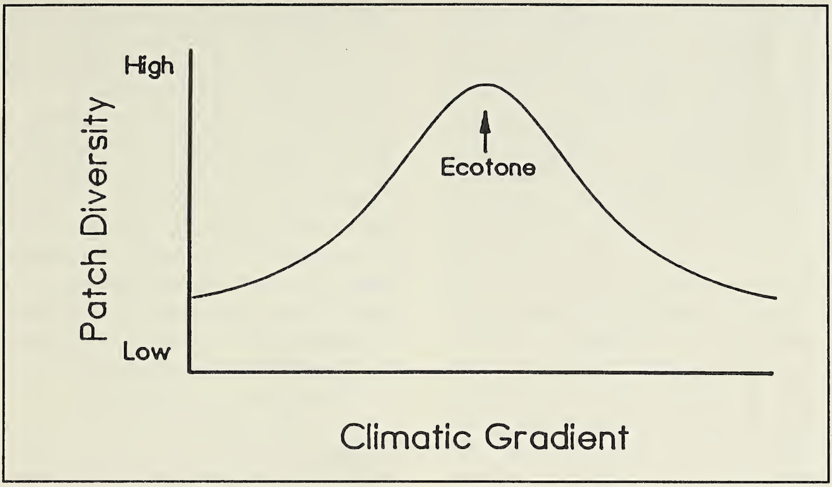

Figure 3. Spatial diversity of habitat patches within biomes and the ecotone that separates them.

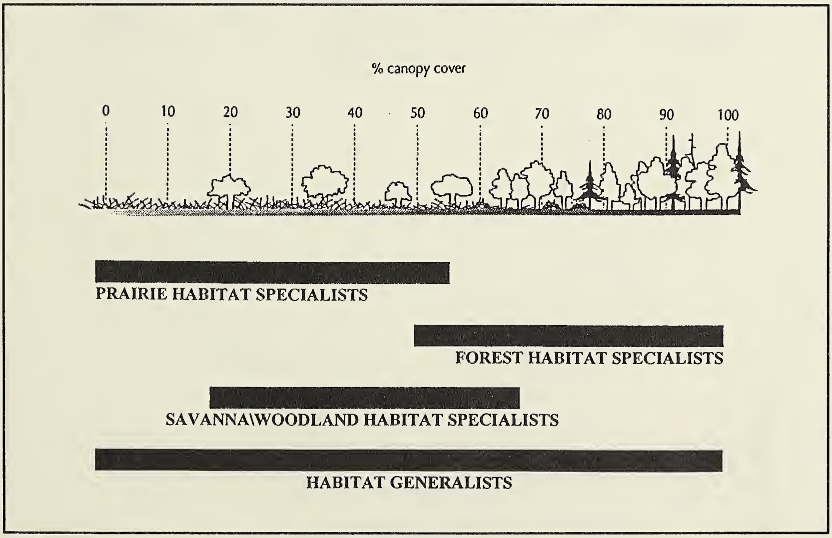

Figure 4. The range of habitat patches found in the Midwestern oak savanna-woodland ecotone and how four categories of species are distributed among patches differing in canopy cover.

deciduous forest in southern Wisconsin. Bird species lists for these 26 sites (ranging from 19 to 54 ha in size) were assembled during multiple visits during the breeding season. Reflecting the relatively small size of the sites, the number of bird species detected on the oak savanna-woodland sites ranged from 19 to 46, out of a potential total species pool of about 70 species recorded in the ecotone. The percent woody cover at the site and the surrounding landscape (within 1 km of the site) was assessed on air photos. Each species of bird was assigned an "affinity value," ranging potentially from 0 for species with strong prairie affinity to 100 for species with a strong forest affinity. These affinity values were based on the percentage of the species' geographic range that lies within the deciduous forest biome, determined from range maps prepared by Sauer et al. (1996). An overall "bird community index" was calculated as the mean affinity value for all of the bird species recorded at a site.

As expected, the prairie sites had lower bird community indices (<55) than the forest sites (>70). Among oak savanna and woodland sites with intermediate indices, there was a significant correlation between the % woody cover at a site and the bird community index (Figure 5), indicating that as an ecotonal patch became more woody it was inhabited by birds with a stronger affinity to forest. The coefficient of determination for this relationship was 0.202.

In a second analysis of these bird data, I examined the relationship between each site's bird community index and the percent woody cover on the landscape surrounding

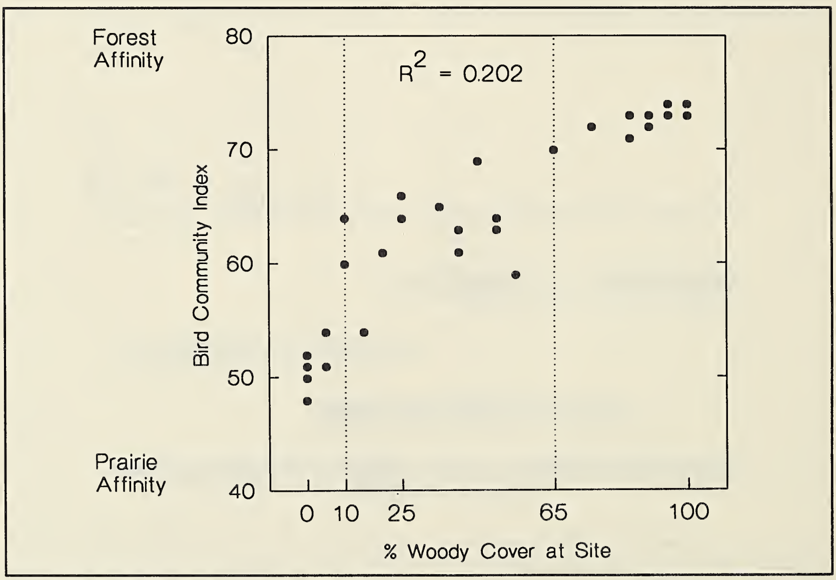

Figure 5. Biogeographic affinities of the bird communities in 26 patches of habitat in Wisconsin that varied in percent woody cover at each site.

the site. Among oak savanna and woodland sites, there was a significant correlation between the percent woody cover on the surrounding landscape and the site's bird community index (Figure 6). But, in this case, the coefficient of determination was 0.804.

These results highlight how important the context of an ecotonal patch can be in determining the composition of the animal community. At least for birds, it appears that the composition of the community in an ecotonal patch is influenced more by characteristics of the surrounding landscape than by characteristics of the ecotonal patch itself. Entomologists who have collected widely around the Midwest also report a similar pattern in the composition of the lepidopteran communities associated with oak savannas and woodlands (L.A. Ferge, personal communication). Hence, two identical patches of oak savanna-woodland could have very different animal communities, depending on whether the surrounding landscape is dominated by closed (forest) or open (prairie) conditions. This relationship reinforces the view that the animal community associated with patches of oak savanna and woodland can be highly variable depending on landscape context.

Population Dynamics in Biome Ecotones and Patch Ecotones

If, as I have predicted, ecotones are often inhabited by sink populations of species from adjacent ecosystems, there should be evidence of reduced fitness among individuals living in transition zones (i.e., sub-

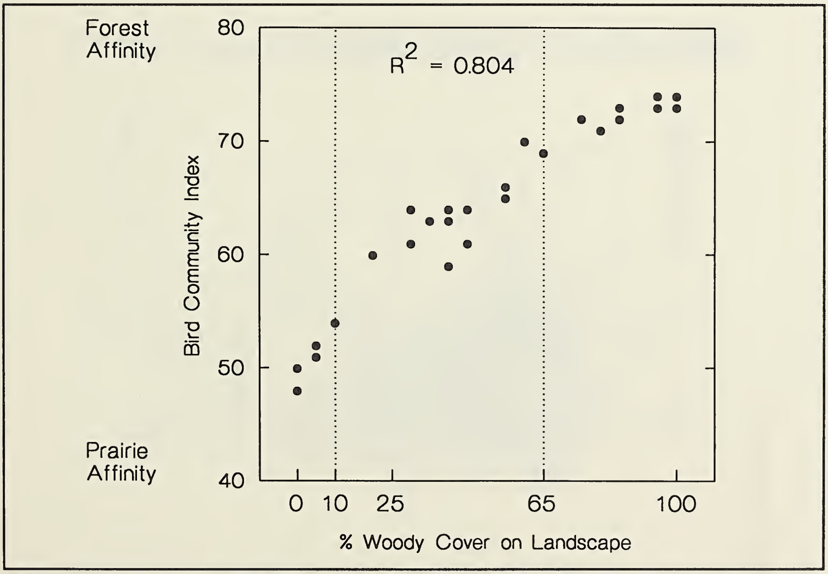

Figure 6. Biogeographic affinities of the bird communities in 26 patches of habitat in Wisconsin that varied in the percent woody cover on the landscape within 1 km of each site.

standard rates of reproduction and survival in ecotones as compared to biomes or patches). Using data that my students and I have collected for several species of birds that breed in the oak savanna-woodland region of Wisconsin, I find just such evidence at both the biome scale and the landscape scale.

For a few birds that have the centers of their geographic ranges in either the deciduous forest or prairie biomes, but have the margins of their ranges in the Midwestern oak savanna-woodland ecotone, there is useful information on geographic variation in reproductive performance. Basili et al. (1998) studied the breeding biology of Dickcissels throughout their geographic range (Figure 7), which is centered on the tallgrass prairie but extends into the oak savanna-woodland ecotone of the Midwest. They documented longer nesting seasons, larger clutches, higher nest success, and higher productivity in the core of the Dickcissel's range than at the periphery. Nolan (1978) studied the breeding biology of the Prairie Warbler, which, despite its name, has its range centered on the deciduous forest biome (Figure 8). Comparing his data on nesting success near the core of the range with data from the North American Nest Record Card Program for the periphery, it appears that nesting success is below average for this species at the Midwestern edges of its range: 1.6 young per pair in Illinois, Missouri, and Arkansas (n = 46) versus 2.2 young per pair in

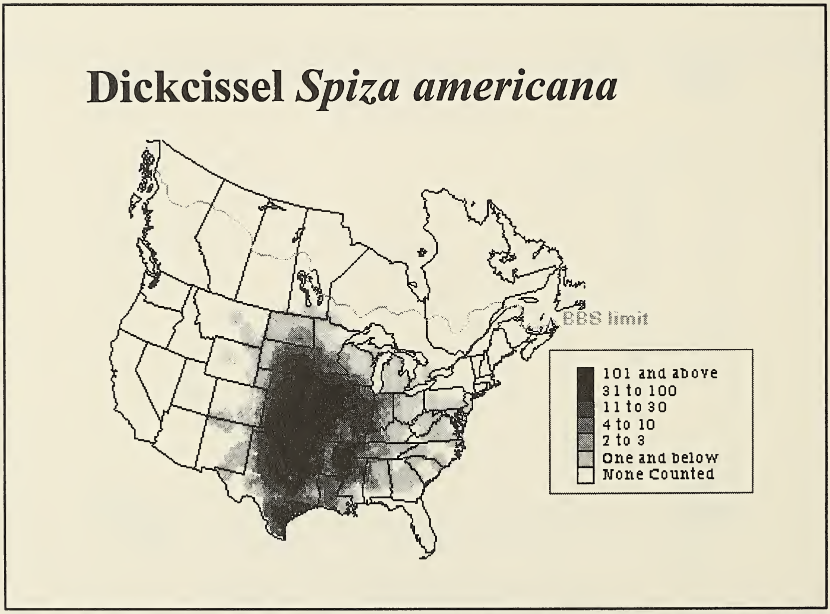

Figure 7. Geographic range of the Dickcissel during its breeding season in North America (from Sauer et al. 1996).

southeastern Indiana (n = 129). It is difficult to know whether or not the patterns shown by these two species are typical of other birds because few studies have examined geographic variations in reproductive performance throughout the ranges of appropriately distributed species.

There should also be evidence that species characteristically associated with ecotones (endemics to biome ecotones or edge species in patch ecotones) have high levels of fitness in transition zones. For the few birds that have portions of their geographic ranges centered on the Midwestern oak savanna-woodland ecotone (e.g., Bell's Vireo), there are too few data on reproductive performance across their range. Hence, I can not demonstrate that their fitness is higher in the ecotone.

Within the Midwestern oak savanna-woodland ecotone there are useful data on how important vital rates vary among patches and their associated ecotones, especially how nesting success of birds varies between closed (forest) and open (grassland) habitats and across the transition zones between them. Over the years, my students and I have accumulated relevant data on the nest success—calculated using the Mayfield (1961) method—of 22 species of songbirds that nested in Midwestern habitats that ranged from patches of closed forest to patches of open grassland. I categorized these birds as either forest birds (Acadian Fly-

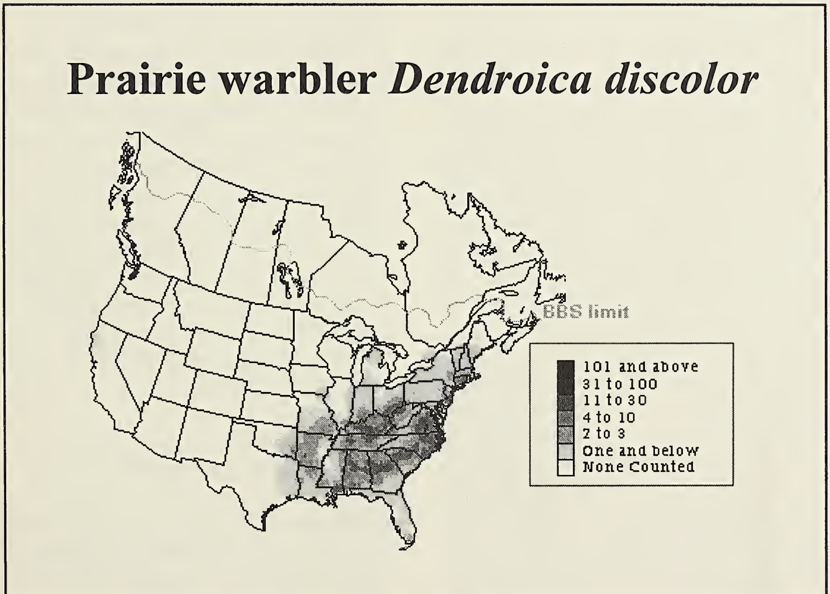

Figure 8. Geographic range of the Prairie Warbler during its breeding season in North America (from Sauer et al. 1996).

catcher, Eastern Wood-pewee, Wood Thrush, Red-eyed Vireo, Ovenbird, Scarlet Tanager, Rose-breasted Grosbeak), grassland birds (Dickcissel, Savannah Sparrow, Grasshopper Sparrow, Bobolink, Eastern Meadowlark, Western Meadowlark), or edge birds (American Robin, Brown Thrasher, Gray Catbird, Yellow Warbler, Northern Cardinal, Indigo Bunting, Rufous-sided Towhee, Field Sparrow, Song Sparrow, American Goldfinch), depending on the habitat where they normally nest.

Forest birds had higher nest success when the area within 50 m of the nest had over 65% woody cover (54%, n = 112) than in areas with a lower percent woody cover (21%, n = 46). Grassland birds had higher nest success when the area within 50 m of the nest had less than 10% woody cover (48%, n = 195) than in areas with more woody cover (16%, n = 104). Edge birds almost always nested where there was 10–65% woody cover within 50 m of the nest, so comparisons between forest, oak savanna-woodland, and grassland were impossible.

Proximity to the edge of a habitat patch and patch size are strong predictors of the success of bird nests. Temple and Cary (1988) have shown that nesting success of Midwestern forest songbirds declines when nests are in small patches of forest near an edge between forest and open habitat. Johnson and Temple (1986, 1990) have shown that nesting success of Midwestern grassland birds declines when nests are in small patches of prairie near a wooded edge.

These impacts of patch size and proximity to edges on nest success and the variations in nest success across a range of habitat conditions highlight the problems that many species of birds encounter in a landscape composed of a complex mosaic of habitat patches. For many of the birds that nest in the mosaic of patches typical of the Midwestern oak savanna-woodland ecotone, fitness is reduced in small patches of their preferred habitat and where that preferred habitat is near an ecological edge.

Unfortunately, relevant population data have been collected for few of the animal species that occur in the Midwestern oak savanna-woodland ecotone. An avian bias is unavoidable because most of the relevant data are available for birds. Nonetheless, the available evidence is consistent with the proposition that in this biome ecotone—and the ecotonal patches within it—species that have geographic ranges centered on adjacent biomes and habitat preferences for large contiguous patches of either forest or prairie have reduced fitness. It is difficult to know if this situation pertained in pre-settlement times, but recent events in the ecotone and adjacent biomes have exacerbated the problems of maintaining viable populations in the Midwestern oak savanna-woodland region. As source populations in the deciduous forests and tallgrass prairies have suffered the consequences of habitat loss and fragmentation, and as the landscape within the oak savanna-woodland ecotone has been extensively altered, many species at the edges of their ranges have declined in the Midwest (Leach and Ross 1995). The result of these changes is that the animal communities of the Midwestern oak savanna-woodland ecotone have different patterns of richness and composition today than they had in the past.

Scale and Context Are Crucial for Preservation and Restoration

Midwestern oak savannas and woodlands are among the most endangered ecosystems in North America (Haney and Apfelbaum 1990, Leach and Ross 1995). Central goals of conservationists concerned about them are to preserve and restore examples of these special environments that can support the rich biotic communities typically associated with the ecotone. Much has been written about restoring and managing the ecotone's plant communities (e.g., Fralish et al. 1994, Leach and Ross 1995), but relatively little has been written about the animal communities. There is clear evidence that some of the best remaining examples of oak savannas and woodlands, many already protected as nature reserves, have severely deficient animal communities. The 14 patches surveyed in this study collectively supported less than half of the potential bird species associated with the habitat. Furthermore, the methods for restoring an intact animal community to oak savannas and woodlands—and then maintaining it—have yet to be developed.

Borrowing a line from a recent Hollywood movie, I believe conservationists have been exhibiting the "Field of Dreams Syndrome." Conservationist have naively assumed that "if you build it, they will come." That is to say, if you carefully restore the plant community, the animal community will spontaneously reoccupy the site. But today's remnant oak savannas and woodlands are unnaturally small, isolated, degraded, and out of their natural context, and it will be very difficult for the typical animal community to either reassemble itself or maintain itself over time. Few of the key components of the community (i.e., ecotone specialists, prairie specialists, or forest specialists) will thrive under current conditions.

Small, isolated patches of oak savanna and woodland will be unlikely to support viable populations of ecotone endemics, regardless of whether they have survived as relics or have been reintroduced. Without adjacent or nearby source populations of forest and prairie habitat specialists, the richness and composition of the animal community in an ecotonal patch of oak savanna or woodland will not be typical because these species will not persist. The full community can only exist when an ecotonal patch receives dispersing individuals from source populations of both forest and prairie. Some remnant oak savannas and woodlands are adjacent to patches of either forest or prairie, but few have both nearby. Furthermore, in the highly fragmented landscape of today's Midwest, most patches of forest and prairie are too small to support source populations that can enrich the communities of oak savannas and woodlands. Small patches of oak savanna and woodland, therefore, lose their typical animal community and, instead, have communities that mirror the species associated with surrounding disturbed lands.

What do the findings presented in this paper mean for efforts to preserve the biological diversity of these ecological systems? First, ecotonal patches of oak savanna and woodland managed for conservation should be as large as possible, and preserving and restoring the largest remnants should be the highest priorities. These will be the sites most likely to retain viable populations of the endemic animals of the ecotone and to have potential for their successful reintroduction. Many, perhaps most, of the sites being managed and restored today encompass only tens or hundreds of hectares and appear to be too small to support many animals that are typical of the ecotone. Second, ecotonal patches of oak savanna and woodland should be situated in a context of adjacent large patches of prairies and forests in order to maintain their full complement of animal species. Oak savannas and woodlands with only forest or prairie patches nearby can be expected to have an animal community skewed towards a species composition reflecting the adjacent habitat. Small, isolated sites surrounded by developed lands will have an animal community dominated by generalists. Third, efforts to restore oak savannas and woodlands must include more reintroductions and intensive management of wildlife; it is not enough to merely restore the plant community and leave the animal community to chance. The methodologies for managing these wildlife species remain to be perfected. Finally, conservationists should identify—and focus their efforts on—those rare sites around the Midwest where the requisite combination of scale and context either occurs or can be recreated. It is there that the best opportunities exist for recreating the rich biological diversity of this ecotone by accommodating its animals as well as its plants.

Acknowledgments

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Susan Will-Wolf and Forest Stearns

Characterization of Dry Site Oak Savanna in the Upper Midwest

Abstract *Oak savanna vegetation on dry sites in the upper Midwest can be divided into two groups based on current literature. Dry sand savanna is found on low-nutrient, well-drained sandy soils, over sand, sandstone, or other acidic parent material. Trees are usually black oak group species. "Brush prairie," "scrub oak," or stunted "oak grove" structure is more characteristic than scattered single trees. Historically, dry sand savanna occurred in relatively large patches in the landscape. In contrast, dry calcareous savanna occurs on extremely thin or excessively well-drained soils with low water availability but moderate nutrient status, over calcareous or inert parent material. Trees are usually white oak group species, found as scattered single trees or small groves. Historically, dry calcareous savanna occurred as scattered small patches. Little bluestem, Pennsylvania sedge, and leadplant are common ground layer plants of both groups. Heath family species, lupine, sand fame-flower and goat's rue are examples of characteristic ground-layer plants of dry sand savannas. Snowberry, the horse-gentians, and tick-trefoils are examples of ground-layer plants found in dry calcareous savanna. The two types of dry site savanna must be distinguished for research, restoration, and management planning.*

Savanna vegetation associated with dry, low productivity sites in the Great Lakes region (Figure 1, Chapman et al. 1997) can be divided into two general groups (Figure 2) based on a review of current literature (including much "gray literature" that is difficult to access). Dry sand savanna is found on low nutrient sandy soils with low water holding capacity or over sand or other acidic parent material. Dry calcareous savanna occurs on extremely thin or excessively well-drained soils with moderate nutrient status and medium to fine texture, overlying calcareous or insoluble parent material. Oak species of the

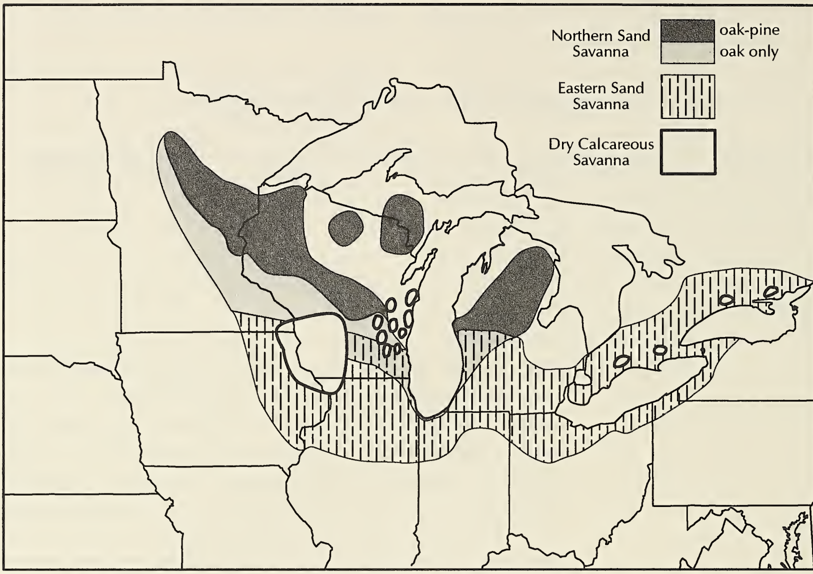

Figure 1. Distribution of dry soil oak savanna in the Great Lakes region, indicating the geographic area within which each vegetation type occurs. The location of the regional vegetation transition zone is approximated by the southern boundary of oak-pine Northern Sand Savanna. For dry calcareous savanna, sections delineated by a heavy solid line suggest the areas in which they occur. The largest and most western of these areas is the Driftless Area (see text). Map copyright Cambridge University Press, reprinted from Figure 8-1 of Will-Wolf and Stearns (in press) with the permission of Cambridge University Press.

subgenus *Erythrobalanus,* the black oak group, are characteristic of dry sand savanna, while oak species of the subgenus *Lepidobalanus,* the white oak group, dominate the tree layer of dry calcareous savanna. Thin-soil white oak-complex savanna and sandy soil black oak-complex savanna both grade into bur oak *(Quercus macrocarpa)* and/or black *(Q. velutina)* and white oak *(Q. alba)* savanna on deeper, higher nutrient, and less droughty soils (Figure 2). In southwestern Ontario dry calcareous savanna ("limestone savanna") and dry sand savanna ("sand barrens") remnants were clearly separated based on species composition (using principal coordinates ordination and cluster analysis, Catling and Catling 1993). These two savanna types have not been formally separated in the western Great Lakes region, but such an analysis would be useful.

Our distinction of dry site oak savanna types is useful for research, restoration, and management planning in several ways: (1) dry sand savanna and dry calcareous savanna differ floristically, so investigation of dis-

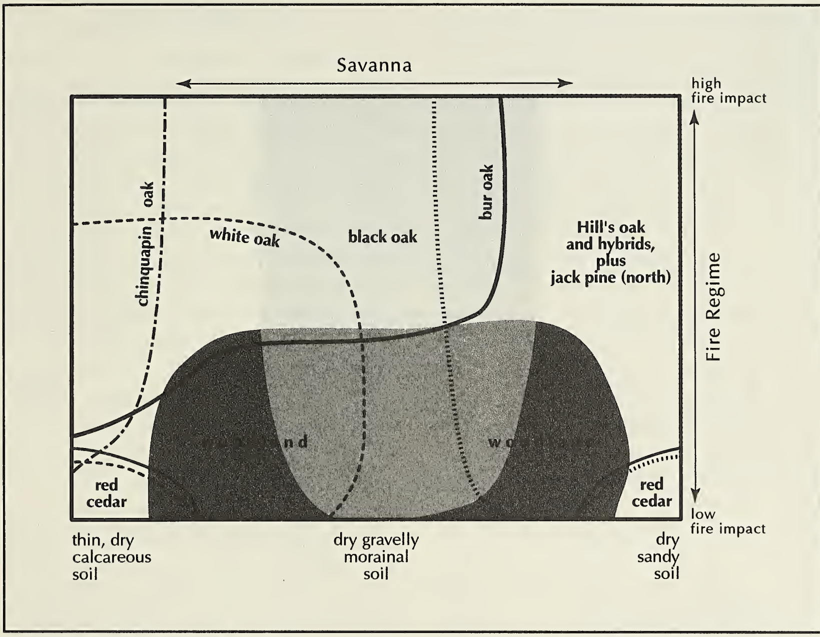

Figure 2. Distribution of tree species and savanna physiognomy along soil nutrient and fire frequency gradients for upper Midwestern dry savanna sites. Only dry site environments are represented in this diagram. However sites at the extremes of the soil nutrient gradient are also usually drier than those in the middle. Great Lakes alvar communities (see text) may fit into the dry calcareous, low fire impact region of this model.

tribution and composition should be separated, and planting lists and composition goals for management should differ; (2) management goals and expectations for structure and physiognomy should differ; (3) landscape design of preserves can differ. Since historically dry calcareous savanna sites were small and isolated, small preserves will probably be adequate to conserve rare species. Conversely, because many dry sand savannas were once extensive, species requiring large areas were part of the community. Large preserves are needed to maintain that suite of area-sensitive species. We focus in this paper on presenting species lists for different dry site oak savanna types.

Vegetation physiognomy and species composition in the Great Lakes region are related closely to interaction of fire frequency and intensity (as influenced by landscape structure and climate, Grimm 1985, Leitner et al. 1991, Will-Wolf and Montague 1994) with broad edaphic gradients (Grimm 1984, Bowles and McBride 1994). Vegetation classification, which is commonly used to define vegetation units for mapping and for management, often incorporates the assumption that site environment determines site vegetation composition and structure. Recent savanna classifications for the upper Midwest have emphasized that variation in disturbance regime, especially fire, has a strong influence on vegetation structure and composition that can be independent of site environment (Homoya 1994, Faber-Langendoen 1995, Haney and Apfelbaum 1995). Vegetation-environment relationships (see Roberts 1987) that appear to be static and deterministic in dry sand savanna complexes (e.g., Botts et al. 1994) may result from artificially uniform disturbance regimes operating over relatively short time scales in the recent past. The shifting mosaic model of vegetation dynamics (Shuey 1994, Will-Wolf and Stearns in press), which emphasizes the importance of disturbance for vegetation structure and composition, appears a more useful model for guiding conservation and restoration practices. Species lists and summaries of species relative importance should thus always be used as guidelines rather than as firm restoration targets or measuring sticks for restoration and management success.

We compiled preliminary lists from literature with species characteristic of dry sand savanna (with two subgroups) and dry calcareous savanna (Tables 1 and 2). A "characteristic" species was reported in most of the relevant studies spread across the range of a savanna type, but was absent or found irregularly in other types. Several common ground-layer species appear to be characteristic of all types of dry site oak savanna and woodland (Table 1), for example little bluestem *(Schizachyrium scoparium)*, Pennsylvania sedge *(Carex pensylvanica)*, and leadplant *(Amorpha canescens)*. Many of the species characteristic of either major group (Table 1) are relatively uncommon.

Dry Sand Savanna

Distribution

Dry sand savanna is associated with sandy (85–95% sand), acidic (pH 4.3–6.0), low nutrient (420–1,025 ppm C, 628–1,500 ppm N), droughty (AWC 14–60%) soils (Curtis 1959, White 1983, Anderson and Brown 1986, Udvig 1986, Tester 1989, Leach 1996). These soils are usually found on outwash plains, sandy lake beds, and dune systems relatively near former glacial margins. In the early 1800s, dry sand oak savanna covered large areas in the western Great Lakes region. Today there are scattered large and small remnants present (Will-Wolf and Stearns in press).

A vegetation transition zone (the "tension zone" in Wisconsin, Curtis 1959) passes through Minnesota, Wisconsin, and Michigan, trending northwest to southeast. North and east of this zone, mixed conifer-deciduous tree vegetation grows under a climate of cool summers and long winters with continuous snow cover. South and west of this zone, deciduous trees predominate, the climate has warm summers, and winters often have only sporadic snow cover. The general location of the transition zone coincides with the southern limit of oak-pine Northern Sand Savanna (Figure 1).

For dry sand savanna, scrub oak and "brush prairie" structure (open herbaceous areas interspersed with dense clumps of short-statured trees or shrubs) are more characteristic than is classic savanna structure (scattered stately trees with wide crowns). The black oak group species characteristic of sand savanna are relatively more fire sensitive than white oak group species, and they grow slowly on low nutrient sites. Frequent or intense fire can produce scrub oak structure, which was common at the time of European settlement (Rodgers and Anderson

Table 1. Vascular plants characteristic of dry site oak savanna. Species in the column on the left are common to both dry calcareous and dry sand savanna. Species in the two columns to the right are those additional species characteristic of either one or the other, but not both. The number of states where the species is listed for conservation is given in parentheses. These lists are summarized from Whitford and Whitford (1971), White (1983), Henderson and Long (1984), Glenn-Lewin and VerHoef (1988), Post (1989), Catling and Catling (1993), Homoya (1994), Kline and McClintock (1994), Faber-Langendoen and Davis (1995), Maxwell and Givnish (1995), Anderson et al. (1996), and Haney and Apfelbaum (1997). Nomenclature follows Gleason and Cronquist (1991).

Dry Soil Oak Savanna	*Dry Calcareous Savanna*	*Dry Sand Savanna*
Trees	**Trees**	**Trees**
Quercus macrocarpa	*Carya ovata*	*Quercus ellipsoidalis*
Prunus serotina	*Quercus alba*	*Quercus velutina*
	Quercus muehlenbergii	
Shrubs	**Shrubs**	**Shrubs**
Ceanothus americanus	*Cercis canadensis*	*Comptonia peregrina*
Cornus racemosa	*Lonicera hirsuta*	*Gaylussacia baccata*
Corylus americana	*Rhus aromatica*	*Salix humilis*
Rosa carolina	*Symphoricarpos spp.*	*Vaccinium angustifolium (1)*
	Viburnum rafinesquianum	
	Zanthoxylum americanum	
Herbs	**Herbs**	**Herbs**
Amphicarpaea bracteata	*Asclepias viridiflora*	*Arabis lyrata*
Amorpha canescens (1)	*Astragalus neglectus*	*Artemisia caudata*
Andropogon gerardii	*Besseya bullii* (6)	*Asclepias amplexicaulis* (1)
Aster oolentangiensis	*Carex sparganioides*	*Calamovilfa longifolia*
Carex pensylvanica	*Carex umbellata*	*Cyperus filiculmis*
Comandra umbellata	*Circaea lutetiana*	*Cyperus lupulinus*
Coreopsis palmata	*Cirsium altissimum*	*Gaultheria procumbens*
Danthonia spicata	*Desmodium glutinosum*	*Helianthemum canadense*
Euphorbia corollata	*Desmodium nudiflorum*	*Koeleria pyramidata*
Lespedeza capitata	*Oxalis violacea* (1)	*Lechea intermedia* (3)
Monarda fistulosa	*Penstemon hirsutus*	*Leptoloma cognatum*
Panicum villosissimum	*Phryma leptostachya*	*Liatris aspera*
Schizachyrium scoparium	*Pycnanthemum virginianum*	*Lupinus perennis* (1)
Smilacina racemosa	*Triosteum aurantiacum*	*Monarda punctata*
Smilacina stellata	*Triosteum perfoliatum*	*Panicum depauperatum*
Solidago nemoralis		*Panicum oligosanthes*
Sorghastrum nutans		*Pteridium aquilinum*
		Scleria triglomerata (3)
		Solidago speciosa
		Stipa spartea (1)
		Talinum rugospermum (3)
		Tephrosia virginiana (1)

Table 2. Vascular plants characteristic of either Northern Sand Savanna or Eastern Sand Savanna, but not both. A site might have one of these sets of species, in addition to those species common to all dry soil savanna, and all dry sand savanna, which are listed in Table 1. Starred species have primarily western North American distributions. Number of states where the species is listed for conservation is given in parentheses. See legend, Table 1, for sources from which these lists were summarized.

Dry Sand Savanna	
Northern Sand Savanna	*Eastern Sand Savanna*
Trees	**Trees**
Quercus ellipsoidalis — characteristic	*Quercus velutina* — characteristic
Quercus rubra — local	*Quercus marilandica* — local
Shrubs:	**Shrubs:**
Corylus cornuta	*Juniperus communis*
	Rhus copallinum
	Rhus typhina
Herbs:	**Herbs:**
**Artemisia ludoviciana* (1)	*Aster linariifolius* (2)
Baptisia bracteata	*Calystegia spithamea*
**Bouteloua hirsuta*	*Chrysopsis camporum*
Dalea candidum	*Coreopsis lanceolata*
Gnaphalium obtusifolium	*Krigia virginica* (2)
Helianthemum bicknellii (1)	*Lechea mucronata*
Helianthus x *laetiflorus*	*Lechea pulchella*
Hieracium kalmii	*Panicum colombianum* (2)
Hieracium longipilum	*Viola sagittata*
Hedyotis longifolia	
Krigia biflora	
Liatris cylindracea	
Physalis virginiana	
Scutellaria parvula (3)	
**Senecio plattensis*	
Solidago ptarmicoides	
**Sporobolus cryptandrus*	

1979), but since has become much less common with fire suppression (Curtis 1959, Bowles and McBride 1994).

Subdivision

Haney and Apfelbaum (1995) divide Great Lakes region dry sand savanna into Northern Sand Savanna and Eastern Sand Savanna. These groups differ in general geographic location within the Great Lakes region, with overlap in Wisconsin and Michigan (Figure 1). Northern Sand Savanna, in the northern and western parts of the region, characteristically has Hill's or northern pin oak *(Quercus ellipsoidalis)* and hybrids, as described later. Eastern Sand Savanna, in the southern and eastern parts of the region, has black oak as the characteristic tree species, and Hill's oak is absent or is a minor component. In contrast, Pruka and Faber-Langendoen (1995) include all dry sand savanna south of the climate transition zone and east of Michigan in a single "Black oak-lupine" savanna type. Faber-Langendoen (1995) combines black oak and Hill's oak sites for most woodland and savanna groups, which are then subdivided by physiognomy and characteristic ground-layer species. We have chosen Haney and Apfelbaum's (1995) classification for several reasons: (1) it recognizes the similarity of dry sand oak savanna north and south of the vegetation transition zone and emphasizes a floristic distinction between the northern and western vs. the southern and eastern parts of the Great Lakes region (*not* following the traditional vegetation transition zone); (2) Northern and Eastern Sand Savanna appear to be distinguished by a suite of species, not just black vs. Hill's oak; (3) it provides a model for comparing Northern Sand (oak) Savanna and jack pine barrens where they both occur in the northern part of the western Great Lakes region. Jack pine barrens likely result from a disturbance regime of infrequent (25–40 year) intense fires, with oak present as scattered small shrubs. Oak dominates under a regime of frequent, less intense fires or European management regimes including fire suppression and loss of jack pine seed source (Whitney 1987, Pregitzer and Saunders in press; Will-Wolf and Stearns in press).

The dry sand savanna groups share several common characteristic ground-layer species, such as huckleberry *(Gaylussacia baccata),* bracken fern *(Pteridium aquilinum),* and blueberry *(Vaccinium angustifolium).* They also share several uncommon characteristic species (Table 1). Some of these are state-listed for conservation: wild blue lupine *(Lupinus perennis),* sand fameflower *(Talinum rugospermum),* and goat's rue *(Tephrosia virginiana).* Most of the ground-layer species characteristic of either Northern or Eastern Sand Savanna (Table 2) are relatively uncommon.

Northern Sand Savanna Composition

Northern Sand Savanna (Figure 1) occurs in the western Lake States. The most characteristic tree, Hill's oak (Table 2), hybridizes extensively with black oak south of the vegetation transition zone (Curtis 1959) and with northern red oak *(Q. rubra)* north of that zone (Gleason and Cronquist 1991). White oak and bur oak are also found occasionally. Jack pine *(Pinus banksiana)* is frequently found in low density north of the vegetation transition zone. Characteristic ground-layer species of Northern Sand Savanna include beaked hazelnut *(Corylus cornuta),* two native hawkweeds *(Hieracium kalmii* and *H. longipilum),* orange dwarf-dandelion *(Krigia biflora),* and a goldenrod *(Solidago ptarmicoides),* in addition to four species with primarily western North American distributions and several state-listed species (Table 2). The herbaceous component of Northern Sand (oak) Savanna is moderately similar to that of jack pine barrens in the northern part of the region (Curtis 1959).

Eastern Sand Savanna Composition

Eastern Sand Savanna is found in northern and central Illinois, southern Wisconsin, and southern Michigan (Madany 1981, Pruka and Faber-Langendoen 1995, Rabe et al. 1995), northwestern Indiana (Homoya 1994), northwestern Ohio (Gordon 1966, Brewer 1989), and in southeastern Ontario (Catling and Catling 1993). Black oak is the characteristic tree, with other oak species present (Table 2). Dry sand savanna in central Illinois often has mostly blackjack oak *(Q. marilandica),* but is otherwise similar to other Eastern Sand Savanna sites (Anderson and Brown 1986). Ground-layer composition includes a short list of characteristic species including shining sumac *(Rhus copallinum),* staghorn sumac *(Rhus typhina), Aster linariifolius,* Virginia dwarf-dandelion (*Krigia virginica*), and two pinweeds (*Lechea mucronata* and *L. pulchella*), with three state-listed species (Table 2). Additional species are shared with other dry soil savanna types (Tables 1 and 2).

Dry Calcareous Savanna

Distribution

Dry calcareous savanna, like dry sand savanna, is edaphically restricted, with soils that have moderate nutrient status, are neutral (pH 7.0–7.5), have loam and silt loam texture, but are thin (8–30 cm) or excessively drained (Lange 1989, Catling and Catling 1993, Armstrong 1994). It is found throughout the region (Figure 1), in mostly small areas within complex savanna-woodland-dry prairie landscape mosaics. Examples are found on dolomite ridges in the unglaciated Driftless Area of Wisconsin, Illinois, Minnesota, and Iowa (Figure 1; Faber-Langendoen 1995, Anderson et al. 1996), on thin soils over quartzite bedrock (acid, but insoluble by groundwater) in the Baraboo Hills of southern Wisconsin (Lange 1989, Clark et al. 1993, Armstrong 1994), and on well-drained gravelly calcareous morainal ridges in the Kettle Moraine area of eastern Wisconsin (Henderson 1995). Thin soil over limestone on flat lowlands supports remnants of once more extensive dry calcareous savanna in southeastern Ontario (Szeicz and MacDonald 1991, Catling and Catling 1993).

Dry calcareous savanna is more likely than dry sand savanna to have classic savanna structure; the oak species are relatively fire tolerant, and slow buildup of herbaceous biomass reduces the likelihood of intense fires. The density and cover of woody vegetation have increased as fire frequency decreased. However, severe edaphic conditions have allowed remnants to persist (Will-Wolf and Stearns in press).

Composition

White and bur oak are the most characteristic tree species, while chinquapin or yellow oak *(Q. muehlenbergii)* occurs at either end of the range (Mississippi River valley and southeastern Ontario). Shagbark hickory *(Carya ovata)* is another characteristic species (Table 1). Of the characteristic ground-layer species (Table 2), snowberry (*Symphoricarpos* spp.) is common (Will-Wolf and Stearns in press), while most other species, like the tick-trefoils (*Desmodium* spp.) and the horse-gentians (*Triosteum* spp.), are relatively less common. Several are state-listed (Table 1). The Wisconsin sites share many herbaceous species with dry lime prairies of the same region (Anderson 1954). Ontario dry calcareous savanna (Catling and Catling 1993) has 40% of the prevalent species of Wisconsin oak openings (Curtis 1959) and also shares many species with Great Lakes alvar communities (areas of extremely thin soil over flat limestone or marble bedrock, with sparse, mostly treeless plant cover; Catling and Brownell in press).

Several state endangered, threatened, or special concern species occur on Wisconsin dry calcareous savanna sites as well as dry lime prairie, cliff communities, and cedar glades. They are round-stemmed false foxglove *(Agalinis gattingeri),* churchmouse three-awn or poverty grass *(Aristida dichotoma),* purple milkweed *(Asclepias purpurascens),* purple shooting star *(Dodecatheon radicatum),* creamy gentian *(Gentiana flavida),* violet bush clover *(Lespedeza* *violacea),* slender bush clover *(Lespedeza virginica),* brittle prickly pear *(Opuntia fragilis),* broomrape *(Orobanche uniflora),* prairie parsley *(Polytaenia nuttallii),* cliff goldenrod *(Solidago sciaphila),* and prairie fame-flower *(Talinum parviflorum)* (Clark et al. 1993, Anderson et al. 1996). One rare rush species *(Juncus secundus)* was found on an Ontario savanna (Catling and Catling 1993).

Summary

Dry sand savanna and dry calcareous savanna in the Great Lakes region differ enough in site characteristics, species composition, and structure that they must be treated separately for research, restoration and management planning. We separate dry sand savanna into two subgroups (classification of Haney and Apfelbaum 1995), emphasizing a strong east-west component to floristic differences. This may be as important for dry sand savanna as the more commonly recognized north-south differences between plant communities in the region. The dry sand savanna subgroup classification is preliminary and needs to be confirmed as useful. We welcome comments on the general lists presented here and elsewhere (Will-Wolf and Stearns in press) and additions to the studies surveyed (send to senior author), to facilitate updates of the lists.

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Richard Boudreau

A Sesquicentennial Look at Literary "Firsts" in Wisconsin

In the century and a half since statehood, writers from Wisconsin have reached out from purely local to regional audiences, then on to national, and in some instances, world audiences. Along the way they have garnered prestigious awards in this country, including Pulitzer Prizes and National Book Awards, as well as various citations and recognitions internationally. The state's presses, both small and commercial, and its long-standing literary organizations and support groups have fostered and continue to foster writing of all kinds, underscoring Kentucky poet Jesse Stuart's assessment of Wisconsin as the "writingest state in the union."[1] In celebration of our state's sesquicentennial, it seems particularly appropriate to step back in time and review once more and in depth the antecedents of this rich literary heritage.[2]

Wisconsin's literary beginnings predate even territorial times: the oral traditions of the Native Americans were already centuries old before European contact. But the first actually taken down were orations, recorded by translators or scribes or witnesses at treaty parleys and truces, the earliest dating back nearly three centuries,[3] and including several councils conducted by the Americans as they began taking over the area following the War of 1812.[4] One of the most moving speeches came not from a treaty conference but from a formal surrender, the so-called death-song of the Winnebago chief, Red Bird, at the Portage in 1827.[5] Besides orations there were songs: dream, war, love, hunting; chants, nearly all from religious rituals; and tales, both secular and sacred, particularly from the Ojibwa, Menominee, and Winnebago, who still maintain their dominance in the area. These were collected over the years by various ethnologists, beginning with Henry Rowe Schoolcraft, who married an Ojibwa mixed blood, his most important informant, and including work by Walter James Hoffmann with the Menominee, Paul Radin with the Winnebago, and Frances Densmore with the Ojibwa.[6]

With the inundation of the Americans into what became part of Michigan Territory came the printing press and almost immediately after, the newspaper. The first press was located in the oldest white settlement, Green Bay, and the first newspaper, *The Green Bay Intelligencer,* began its life there December 11, 1833. The first booklet published in what would be Wisconsin was an Ojibwa almanac, printed in 1834 on the Green Bay press,[7] not, as generally believed, Increase A. Lapham's study of the plants and shells on the west shore of Lake Michigan, published two years later in Milwaukee[8] on what was the third printing press in Wisconsin.[9] Lapham's *Wisconsin Gazetteer,* published in 1844, however, was the first book with "durable binding" printed in the Territory.[10] But the earliest book written by a "Wisconsinite" was Dr. William Beaumont's account, published in 1833, of his famous experiments with Alexis St. Martin, whose unhealed wound to the stomach allowed for Beaumont's remarkable research on human digestion.[11]

Such achievements in publishing in a new territory were not remarkable, perhaps, but in June 1842, *The Garland of the West,* appeared—and it was remarkable. It was the first literary magazine in the entire Northwest Territory.[12] Started by Edward Young and Julius H. Kimball in Southport (later Kenosha), it attempted to bring literature, particularly poetry (sentimentality reigned supreme) to the frontier. Its editors had good writers (one, L. P. Harvey, became Civil War governor of Wisconsin, tragically drowning on a visit to the front in 1862; another, Michael Frank, editor of the Southport newspaper, became known as "the father of the free school system" in Wisconsin) and great expectations—but little chance of success. By the third issue, that for August, Young was alone as the editor, and after some delay, he brought out the September and October issues combined as one, signalling difficulties. "Somewhat bleached and cut short of its fair proportions by the fall frosts," the *Milwaukee Courier* wryly noted.[13] Young then relinquished it to the Sholes brothers, Charles C. and C. Latham (later inventor of the typewriter), who changed the name to *Wisconsin Monthly Magazine,* promising to shift its focus to "useful reading matter instead of lovesick trash."[14] Their attempt, however laudatory, failed, but, since no copies are extant, it is not known when the magazine ceased publication.

Newspapers, however, thrived. Besides news of all and sundry, they were filled out with trivia, both informative and humorous, as well as with sketches,tales, and, particularly, verse. Newspapers were most important in fostering poetry in the new territory and state. They printed numerous single poems, called "waifs" by ambitious versifiers, most of whom were women. Famous names among Wisconsinites were Carrie Carlton (Mary Booth Chamberlain of Beloit), Ada F. Moore (Ellen E. Hall Phillips of Stevens Point), Nellie A. Mann (Helen A. Manville of La Crosse), and Nellie Wildwood (Mary Elizabeth Farnsworth Mears of Oshkosh). Each of them eventually legitimized their "waifs" by gathering them into collections published in the '60s and '70s. Despite all of their activity, however, what has been considered the first collection of Wisconsin poetry was written by a man. Adolf Schults, a self-proclaimed exile from Germany, published *Lieder Aus Wisconsin* in 1848, but his ties to Wisconsin are suspect.[15] If not Schults, either Hiram Alvin Reid of Beaver Dam or Orpheus Everts of Hudson, seem to be candidates with collections of poems published in 1856, but their residency seems suspect as well.[16]

That would seem to give Mary Elizabeth Farnsworth Mears the distinction of publishing the first book of verse in Wisconsin, a claim that has often been made.[17] Her long poem, *Voyage of Pere Marquette and Romance of Charles de Langlade or, The Indian Queen,* was printed in Fond du Lac in 1860. The long historical narrative has sometimes been referred to as Wisconsin's first "epic." But there was a much earlier claimant even to that title: *The History of Black Hawk, with which is interwoven a Description of the Black Hawk War and other Scenes in the West* by E. H. Smith, published in Milwaukee originally in 1846. Two years later Elbert (or Egbert) Herring Smith re-published the book with extensive alterations under the title *MA-KA-Tai-Me-She-Kia-Kiak; or, Black Hawk, and Scenes in the West.*[18] Other editions followed, and he evidently spent the rest of his life trying to make a living from his "epic." And since neither Smith's nor Mears's books are collections of poems and since the three male writers mentioned probably do not qualify as Wisconsinites, the honor of the first collection of poetry apparently belongs to Mary Booth Chamberlain (Carrie Carlton); her *Wayside Blossoms* appeared in 1862.

With drama the past is murky and inconclusive. The first play published in the state seems to have been *The Drummer, or New York Clerks and Country Merchants,* edited by a Mrs. Partington and published in Milwaukee in 1851.[19] But Mrs. Partington, a sort of Yankee Mrs. Malaprop, was a fictional creation of Boston printer and journalist, Benjamin Penhallow Shillaber.[20] And since the action of the play takes place in New York City with no apparent tie-in to Wisconsin and since its supposed author was a resident of Boston, it should probably be discounted. The first Wisconsin drama actually performed in Wisconsin, as far as we know, is the one written by the ubiquitous Mrs. Mears. Her play, *Black Hawk,* held the stage for a run of three weeks in Madison[21] about the time of the onset of the Civil War, but it is not known when she wrote it or whether she ever published it.

The first memoir, it has long been assumed, was the still popular and oft-published book by Juliette Magill Kinzie, *Wau-Bun, The Early Day in the Northwest, 1856.* It is primarily the account of her two and a half years at the Portage, 1830-33, with her husband, John Kinzie, Indian Agent to the Indians gathered in the vicinity of Fort Winnebago. More than that, it presents a sympathetic treatment of her nearest neighbors, the Indians, especially of the women. And the memoir delineates the last months of their sojourn there during which the Kinzies share in the restricted rations and near starvation of their neighbors. Written in a lively, engaging style, it is a moving, remarkable account.

But, as it turns out, it is not the first memoir. That achievement belongs to a Dominican priest, Rev. Samuel Mazzuchelli. Shortly after his ordination in 1830 this Italian missionary traveled extensively in the territory from Mackinac Island to Prairie du Chien, serving both Indian and White, Protestant and Catholic. Among other duties he served as chaplain to the second session of the Wisconsin Territorial Legislature which met in Burlington, Iowa, in 1836. On a trip back to his homeland after 12 years in the territory he wrote an account of his labors: *Memoirs, Historical and Edifying Among Various Indian Tribes and Among Catholics and Protestants in the United States of America.*[22] It was published in his hometown, Milan, Italy, early in 1844, about the time he returned to his missionary field in territorial Wisconsin.[23]

If we consider Mrs. Kinzie's book a memoir rather than an autobiography, then the first autobiography in Wisconsin literature was *The Life-Line of the Lone One* by Warren Chase, published in 1857.[24] Though Chase is the subject of his autobiography, he refers to himself throughout in the third person (as did Rev. Mazzuchelli in his *Memoirs*) or as the Lone One. He uses his birth year of 1813 as a starting point and arranges each chapter to cover one decade in his life. It is in the third chapter, 1833–1842, that he arrives in Southport in territorial Wisconsin, nearly destitute, with a very ill wife and a sickly first born. But his fourth chapter is of utmost interest: during that decade he joins a Fourierite socialist group, eventually becoming its leader, establishing in 1844 the communal settlement of Ceresco on land incorporated into the later village of Ripon. While he served as the leader of the "Wisconsin Phalanx," he also became a delegate to both constitutional conventions in Madison and was elected to the first state senate.[25] The Ceresco community disbanded in 1850, perhaps the only utopian community of that era to finish in the black. Chase became a spiritualist minister and moved further west, finally settling in California where he died in 1891.

The first novel in Wisconsin has for years been considered *Bachelor Ben* by Ella Giles, published in 1875, but there are a number of earlier claimants to that distinction. The first novel printed in Wisconsin was published "by a citizen of Milwaukee" in 1857. But with the story set entirely in New York State, it seems reasonable to assume it was written well before the "citizen" moved to Milwaukee. The next novel published was *Walter Ogilby* by Mrs. Kinzie of Wau-Bun fame. It appeared in 1869. That too is set in the East with no tie-ins with Wisconsin. But her second novel, *Mark Logan,* the Bourgeois, published posthumously in 1871, is set in what would become Wisconsin, along the Fox-Wisconsin river route the summer of 1827 (Mark Logan witnesses the surrender of Chief Red Bird). Because the author is certainly a writer with strong Wisconsin ties and because the story is the first involving the state as setting, it would seem to be the clearest choice for Wisconsin's first novel.[26]

Determining what could be called the first Wisconsin short story would be a monumental, if not impossible task. Copyright laws in the United States were confusing, largely ignored, and generally unenforceable; international copyright laws were not in place until much later. That meant that editors could, in effect, reprint tales and stories from any source whatever, including the best writers of the day. Nor, in fact, did the term, short story, exist; it did not come into use until the 1890s. If the first short story by a Wisconsin writer cannot be identified,[27] we can at least suggest a couple of collections that might qualify for the title of the first book of short stories. Both are by George Wilbur Peck: *Peck's Sunshine,* in 1882, which includes some of his longer humorous tales, and *Peck's Bad Boy and His Pa,* in 1883, made up of short episodes in the life of the "Bad Boy." With illustrations alternating almost equally with the text, the latter could also be considered the precursor of the comic strip.[28]

A sesquicentennial seems an ideal time for a reconsideration, and in the review just completed, we have evidence that alters a number of assumptions about our literary past. Increase A. Lapham's booklet of 1836 was not the first pamphlet published in the state, though his *Wisconsin Gazetteer* of 1844 was certainly the first book published here. And the first book written by a Wisconsinite, William Beaumont's treatise of 1833, can be added to the list of literary firsts. *The*

Garland of the West, 1842, is a remarkable first—the first literary magazine in the entire Northwest Territory. The first memoir is clearly that of Rev. Mazzuchelli even though written in Italian and published in Italy in 1844. Mrs. Mears loses two firsts attributed to her, for a book of verse and for the "epic," but gains another, the first play by a Wisconsinite presented in the state. Mrs. Kinzie loses one first, that of autobiography or memoir, but gains a new one, the first novel by a Wisconsinite, *Mark Logan,* published in 1871. And humorist/governor, George Wilbur Peck, appears to have title to the first short story collection published in the state.

With literary antecedents such as these stretching back into the earliest years, how could Wisconsinites fail to recognize and to honor such auspicious beginnings and the prodigious outpouring of writing that has ensued in the last century and more in their state? Perhaps there is no better way to acknowledge such a rich literary heritage than to take note of, and to honor, our present day writers and to search out, read, and cherish good books by Wisconsin authors of whatever era.

Endnotes

[1]As quoted by Clarice Chase Dunn, in "Wisconsin Writes," *Wisconsin Academy Review,* June 1983, pp. 26–27.

[2]The best source to begin such a review is Orrilla T. Blackshear's *Wisconsin Authors and Their Books: 1836–1975* (Madison: Wisconsin Department of Public Instruction, 1976).

[3]"The Cass Manuscripts," republished in *Wisconsin Historical Collections,* Vol. III., (Madison: The State Historical Society, 1856), pp. 152-53, contain short speeches by Fox, Sauk, and Winnebago spokesmen at a parley with the French in 1726.

[4]See, for example, the speech of Sau-sa-man-nee in *Wisconsin Historical Collections,* Vol. X, pp. 143–45. Native American orations are scattered throughout the volumes of this invaluable collection.

[5]"After a moment's pause, and a quick survey of the troops, and with a composed observation of his people, he spoke, looking at Major Whistler, and said: 'I am ready.' Then, advancing a step or two, he paused and said, 'I do not wish to be put in irons. Let me be free. I have given away my life—(stooping and taking some dust between his finger and thumb and blowing it away)—like that' (eyeing the dust as it fell and vanished), then adding, 'I would not take it back. It is gone.'" From Moses M. Strong, "Indian Wars," *Wisconsin Historical Collections,* Vol. VIII (Madison: The State Historical Society, 1879), pp. 262-63. Red Bird died in prison soon after his surrender.

[6]See Henry Rowe Schoolcraft, Algic Researches, 1839; Walter James Hoffman, "The Menomini Indians," *The Fourteenth Annual Report of the Bureau of American Ethnology,* 1896; Paul Radin, numerous books, selections of which form the volume, *The Winnebago Tribe* (Bison Books: University of Nebraska Press, 1970); and Francis Densmore, *Chippewa Music I & II,* Bureau of American Ethnology Bulletin 53, 1913, and *Menomonee Music,* Bureau of American Ethnology Bulletin 102, 1932.

[7]The booklet is referred to in the biography of Rev. Samuel Mazzuchelli by Jo and J. Alderson, *The Man Mazzuchelli: Pioneer Priest* (Madison: Wisconsin House, 1974), Chapter 5 (no page nos.), and again in the Aldersons' article on Mazzuchelli in the *Wisconsin Academy Review,* Summer, 1998. Only one copy of the booklet is known to exist; it is located in the Library of Congress. The only other reference to its being the first published in Wisconsin is found in footnote 13,

page 87, of the *Positio,* or *A Documentary Account of His Life, Virtues and Reputation for Holiness* used as the basis for consideration in the Roman Catholic Church for Rev. Mazzuchelli's beatification, published in Rome in 1989.

[8]See Henry Eduard Legler, "Early Wisconsin Imprints: A Preliminary Essay," *Wisconsin Historical Society Proceedings,* 1904, p. 119; See also Paul G. Hayes, "Increase A. Lapham: A Useful and Honored Life," *Wisconsin Academy Review,* Spring, 1995, pp. 10–15. Of course, it still is assumed to be the first scientific treatise published in Wisconsin.

[9]Legler, 119.

[10]See Legler, p. 120: Increase A. Lapham, *Geographical and Topological Description of Wisconsin* (Milwaukee: P.C. Hale, 1844). This was popularly known as the Wisconsin Gazetteer.

[11]William Beaumont, *Experiments and Observations on the Gastric Juice and the Physiology of Digestion* (Plattsburgh, New York: Allen, 1833). Dr. Beaumont was stationed at Mackinac Island in 1822 when he began to treat St. Martin's wound. Dr. Beaumont then served at Fort Howard, Green Bay, from 1826–28, and at Fort Crawford, Prairie du Chien from 1828–1832, where, from 1829 on, the majority of his experiments were carried out.

[12]See M. M. Quaife, "Wisconsin's First Literary Magazine," *Wisconsin Magazine of History,* Vol. 5, 1, 1921–22, 43.

[13]Quaife, 47.

[14]Quaife, 47.

[15]See Oscar Wegelin, "Historical Fragments: Wisconsin's First Versifiers," *Wisconsin Magazine of History,* Vol. 1, 1921–22, pp. 64-67. The book, written in German, was published in Germany (by J. Badecker of Elberfeld and Iserlohn); it's possible that Schults never lived in Wisconsin or that he visited here for a short time only.

[16]"Hiram Alvin Reid, *The Heartlace and Other Poems* (the author, 1856)" according to Blackshear, but the book was published in Davenport, Iowa, that year, and he claimed many years later that it was the first book of poetry printed in Iowa, not Wisconsin. "Orpheus Everts, *Onawequah, An Indian Legend and Other Poems,* (Hudson: Times Printing Office, 1856)" according to Blackshear, but the book was published that year in La Porte, Indiana, not in Wisconsin. He was a member of the law firm of Tuttle, Reymart & Everts in Hudson from 1859 to 1861. Though Reymart became prominent in Wisconsin, Everts disappeared from sight.

[17]Among many others over the years, Legler, p. 121. But even as recently as Janet Ela's "Sculptor Helen Farnsworth Mears" in *Wisconsin Academy Review,* March, 1986, that claim was repeated. The Helen Farnsworth Mears of the article title was one of Mrs. Mears's three talented daughters.

[18]See Oscar Wegelin, "Historical Fragments: Wisconsin's First Versifiers," *Wisconsin Magazine of History,* Vol. 1, No. 1, 1918. Written "by a Western Tourist" this book was published in New York in 1848 and was the one Legler discounted because he did not think the author had residency in Wisconsin. But in an interesting aside, the whole story of the "Wisconsin Bard" is rendered in *The Chronicles of Milwaukee* by A. C. Wheeler, 1861. Smith, a teacher in a rural school near Southport, took himself seriously as a poet. He was apparently led on by others in what they intended as a massive joke which boomeranged when Smith began to profit from his "epic."

[19]Oscar Wegelin, "An Early Wisconsin Play," *Wisconsin Magazine of History,* Vol. 1, No. 4, pp. 307–8.

[20]This is all very curious. Wegelin was apparently aware of the "true" Mrs. Partington because he mentions Shillaber, though Wegelin de-

cides Shillaber had nothing to do with the piece. Since there is no other information available, we can only conjecture: the manuscript was written by Shillaber and printed by a friend; the manuscript was pirated; the manuscript was written and printed by persons unknown who might or might not have lived in Wisconsin.

[21]Publius V. Lawson, "Mary Elizabeth Mears: 'Nellie Wildwood,'" *Wisconsin Historical Society Proceedings,* 1916, p. 255. The claim is actually made by her daughter, Mary Mears, in a letter she wrote to Lawson shortly after her mother's death.

[22]*Memorie Istoriche ed Edificanti d'un Missionario Apostolico del'Ordine dei Predicatori fra Varie Tribu di Selvaggi e fra I Cattolici e Protestanti negli Stati-Uniti d'America* (Milano: Bonardi-Pogliani, 1844).

[23]Alderson, Chap. 10 and "Sources," at the end of the book. His *Memoirs* were essentially unknown to Wisconsinites until their translation in 1915 by Sister Mary Benedicta Kennedy, O.S.D., the order that Rev. Mazzuchelli founded, headquartered at Sinsinawa. The book was reprinted in 1967. Rev. Mazzuchelli founded many parishes in southwest Wisconsin, eventually settling in Benton, Wisconsin, where he served as pastor until his death in 1864.

[24]Warren Chase, *The Life-Line of the Lone One; or Autobiography of the World's Child* (Marsh, 1857).

[25]For a succinct account of his life see *Dictionary of Wisconsin Biography* (Madison: The State Historical Society of Wisconsin, 1960).

[26]See Richard Boudreau, "Wisconsin's First Novel," *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 86, 1998. Two other books in Blackshear appear to be possibilities: *Teone* by Rusco (Mary Ann Smith, Milwaukee, 1862), and *The Friar's Curse* by Michael Quigley (Milwaukee, 1870). But neither is a novel; both are long narrative poems in the style of medieval romances.

[27]But in Publius V. Lawson's article, "Mary Elizabeth Mears: 'Nellie Wildwood,'" in *Wisconsin Historical Society Proceedings* for 1916, daughter Mary Mears claims that her mother "was the author of many fugitive poems and stories which appear in editions of the early newspapers of Wisconsin." If so, Elizabeth Farnsworth Mears may hold another first: the writer of the first Wisconsin short story.

[28]The first collection of short stories about which there would be no argument is that of Capt. Charles King: *Starlight Ranch, and Other Stories of Army Life on the Frontier* (Lippincott, 1890).

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Richard Boudreau

Wisconsin's First Novel

What was the first "Wisconsin" novel? The answer to that question has traditionally been *Bachelor Ben,* by Ella Augustus Giles, published in 1875. That assumption has gone unchallenged for years, even in two lengthy books published for the state's centennial in 1948: *The Story of Wisconsin Women* by Ruth de Young Kohler (76) and *The Wisconsin Story* by H. Russell Austin (478). But in this year of Wisconsin's sesquicentennial, it's time to set the record straight: The Giles novel clearly is not the first. A close review of *Wisconsin Authors and Their Books, 1836–1975,* by Orilla Blackshear, turns up around 20 possible candidates for that honor. A few of these can be eliminated for various reasons when cross-checked in *The National Union Catalogue,* but ten possibilities survive.

Even with the shorter list, however, there are still difficulties; it is not a simple task to define what a "Wisconsin" novel should be. Though any definition will probably prove less than satisfactory, let us try one that is at least simple and workable. This would be two-fold: (1) that the writer at the time of composition was or had been a resident of the area and (2) that some part of the novel be set in the area and/or draw to some extent on experiences from that residency, however tangential. In other words, that both the writer and his/her artistic production reflect a Wisconsin connection. With this in mind let us take a closer look at the possibilities.

Two books from the final list turn out not to be novels. The entry in the Blackshear bibliography for Mary Ann Smith's book, *Teone; or, The Magic Maid,* published in Milwaukee in 1862 by the pseudonymous "Rusco," is a long narrative poem in the style of the medieval masterpiece, *The Pearl.* Strange enough to be published in frontier Milwaukee, but even stranger is that it purports to be told around the bunkhouse stove in a Maine logging camp by one of the loggers. And its story of magic, involving the lovely maid, Teone, a prince, a Green Knight, a time frame of a year and a day, and a three days waiting period before the final settlement of accounts, echoes the famous long poem, *Sir Gawain and the Green Knight.* But this story in book form stretches to over 5,000 lines, double that of its model. And the rest is silence: Who was Mary Ann Smith? How did this book come to be written? How did it come to be published on a Wisconsin press?

The second non-candidate is *Trimsharp's Account of Himself,* published originally in 1873, and including a handful of poems at its end. The book is not poetry, however, nor is it finally fiction, but, as its title suggests, an autobiography, though published under a pseudonym. Not an autobiography of an ordinary man—at the time of its writing its author, Harvey A. Fuller, was only 38 years old. Born in upstate New York near Lake Ontario, he grew up on the frontier, first in New York, then in Ohio and Indiana. At the age of 20 he became deathly ill with cholera, and through complications and lingering illness, lost sight in both eyes. After his recovery he attended the newly opened Institution for the Blind in New York City, where he became acquainted with the inspirational Laura Bridgman, who though blind, deaf and mute, lived a full life (Fuller quotes an extensive passage from Charles Dickens's *American Notes* concerning this remarkable woman). After several more adventures he entered Hillsdale College in Michigan, graduating in 1868. At the urging of his friend, Wisconsin poet Will Carleton, Fuller moved to Milwaukee a few years after his autobiography appeared, and lived the rest of his life there, publishing a play and three books of poetry.

With *Amanda: A Tale for the Times,* by W. H. Brisbane, M. D., we begin our look at bona fide novels. Published in Philadelphia in 1848, it is the tale of a beautiful young woman of Cincinnati who exchanges promises with her brother's college friend, James Ballou of Charleston, South Carolina. Along the way she unknowingly arouses lust in one of his classmates, Jack Dundas—the villain. He arranges an elaborate plot of drugging, kidnapping, and transportation to enslavement in New Orleans to achieve his ends. Amanda herself is led to believe she is part Negro, daughter of a slave. But both brother and betrothed, each separately, discover her whereabouts, free her, and have Dundas arrested. Though the preface suggests an attack on "the wickedness of certain Federal and State laws and Judicial Decrees," the story is merely an adventure-romance. And though published as a book, at 12,500 words it is hardly a long short story. William Henry Brisbane (1803–1878) was an active abolitionist in the 1840s, a member of the American and Foreign Anti-Slavery Society. In later years, well after the publication of his tale, he lived in Arena, Wisconsin.

Julia, or Sister Agnes, is certainly a novel, but it is also a tract, first on living a good Christian life and more narrowly a Catholic life (with strong overtones of Jansenism), written by the Rev. John W. Vahey of Milwaukee. Two Irishmen with their young families emigrate to America in 1844, settling as farmers in central Illinois. But the heart of the story is the wooing of Julia, the properly raised daughter of Richard Burke, by John, the atheistic son of James Moran. He is headed for a bad end—corrupted by the public schools, by the university (where he worked on a law degree), and by his inheritance of money. Her God-fearing parents see what he is and will be and forbid Julia further contact with him. Frustrated, Julia elopes to St. Louis, and with his promise to become a Catholic, she marries him. Of course it does not work out: he submits her to a life of misery, heightened by his drunkenness, his hypocrisy, his rages, and his dissipation of the inheritances of both his parents and hers. After five years of hell, Julia is delivered—her husband expires in the throes of delirium tremens. Penniless, she becomes a laundress, eventually enters the convent she had considered entering long before, and dies there at the age of 45. Discerning readers will note that since she was born just prior to her family's departure for America, she must have died in 1889, 14 years after the time of the appearance of the book. That's writing for the eternities! The narrative is not well told: characters, particularly Julia, are manipulated beyond belief. Dialogues are stilted and often turn into diatribes. Even so, the story is a novel, and it appeared in the same year as Ella Giles's *Bachelor Ben.*

Charles Herbert Richards's novel, *Will Phillips, or, The Ups and Downs in Christian Boy-Life,* appeared in 1873. The publisher—not listed in Blackshear (505)—was D. Lothrop of Boston, and the book, categorized as juvenile fiction, was one of 32 titles in the company's Young Folks series. The Union Catalogue contains no entry for the book, though it does for other of his writings. Of the two libraries with copies, neither would release it for interlibrary loan. Oddly enough, there is no copy of it registered in the Library of Congress. A Congregational minister, Richards (1839–1925) lived his last years in Madison, quite likely well after this book was published. In any case the exact year of his move to the state raises the question of whether he could be considered a Wisconsin author at the time of the book's publication.

Several Lives by Thomas Marshall, was published in 1874 under the strange pseudonym, Fasyl Stamford. It is an out and out temperance tract—common enough in that era—and at first sight seems to be a collection of such stories. But it is more than that—or less. It contains the parallel lives of two Chicago men from birth to death. Each chapter contains two parts, one devoted to one man at a particular time in his life, the other to the other man at the same time, the chapter ending, usually ironically, with items from the local newspapers. Albert Smythe, son of a successful businessman, grows up to live the good life, then through his own success becomes an alcoholic. Dick Donner, the son of a drunkard, doomed to alcoholism, late in life after his health has been destroyed by drink, becomes a reformer. The book ends up qualifying as a novel, somewhat unusual in its telling and always with the failings of character and motivation found in tracts, temperance or otherwise. It also contains a curious appendix: a collection of reports for the first months of 1874 of the women's crusade against drink throughout the United States, particularly in the upper Midwest. Thomas Marshall was a resident of Milwaukee at the time of its publication.

Minnie Hermon: or, The Night and Its Morning by Thurlow W. Brown, published in 1854, would seem to be a prime candidate for the first Wisconsin novel. Though it is a temperance tract, a cautionary tale, it is for all that clearly a novel. Thurlow W. Brown was a New York native, a fervid "dry" who edited the temperance newspaper, *Cayuga Chief,* beginning in 1849, when he was 30. In 1854 he moved to Hebron, Wisconsin, for his health, and two years later began editing his paper in Fort Atkinson. In 1857 he changed its name to *Wisconsin Chief* and began including abolitionist fulminations as well. His style of delivery both written and spoken was "vehement, sarcastic, and vitriolic" (Dictionary, 53), and perhaps for that reason he was successful in reviving the ailing temperance movement in the state. The setting for the novel was upstate New

York; that would not disqualify it, but Brown notes in the preface that the story "was commenced two years ago in the *American Temperance Magazine,* but abandoned," and further that "detached chapters . . . appeared in the Chief"—all of this prior to his move to Wisconsin.

There is only one Tucker noted in the Blackshear listing: Mary Eliza Perine Tucker, followed by various pseudonyms and a reference to La Crosse (596). Her novel, *Confessions of a Flirt: "An Over True Tale,"* under the pen-name of Ella Leigh, published in 1865, would seem to qualify as an early Wisconsin novel. The citation, however, does not show that the place of publication was Milledgeville, Georgia. Further research reveals that she was married first to a John M. Tucker and later to a James H. Lambert. Her second husband worked for "Brick" Pomeroy on his New York *Democrat,* and for a few months on Pomeroy's La Crosse *Democrat* as well. The La Crosse city directory for 1868–69 lists Lambert as assistant editor of the *Democrat.* It was Mrs. Lambert's 1868 biography, *Life of Mark M. Pomeroy,* editor of the La Crosse *Democrat* and a leader of the Copperheads during the Civil War, that led to complex confusion. David O. Coate, English professor at the La Crosse normal school, assumed that the author of the Pomeroy biography was the La Crosse Mrs. Tucker who had published the book, *Hawthorne Dale,* in 1869 (71).

But the La Crosse Mrs. Tucker's given names were Elizabeth Letitia, and it is certain that she was the mother of Blanche Roosevelt, a moderately successful opera singer and writer, who was born in 1854 in Ohio, shortly before they moved to La Crosse. Thus if she was "Ella Leigh," she would have been scarcely 16 at the time of the birth of her daughter and lived not only in Ohio and Wisconsin but also in Georgia—not impossible, but certainly improbable. The evidence seems overwhelming: Mary Eliza Perrine Tucker, "Ella Leigh," cannot be considered a Wisconsin author. But Elizabeth Letitia Tucker of La Crosse can be. Her book, *Hawthorne Dale,* is, however, neither fish nor fowl, spending 200 pages on English country life and another 200 pages on Masonry (including a description of the first Masonic funeral in La Crosse). The book, not listed in Blackshear at all, is certainly not a novel and so must be disqualified.

Another writer not mentioned by Blackshear and not included in the list of ten referred to earlier is Mrs. E. D. E. N. Southworth, an enormously popular novelist of the mid-nineteenth century. As a young bride she lived in Prairie du Chien from 1841 to 1844 and taught school in Platteville during that time (Campbell, 187). She seems to have used the three year experience on the frontier in only one novel, *India, or The Pearl of Pearl River,* 1856. Serialized three years earlier in *The National Era* (the magazine in which Harriet Beecher Stowe's *Uncle Tom's Cabin* appeared), it originally bore the title, *Mark Sutherland, or Power and Principle.* Though the frontier setting provides the background for about a third of the novel, Mrs. Southworth did not locate the site in Wisconsin but along the Mississippi in Illinois somewhere above Rock Island. Neither her residency nor the setting of her novel, then, are adequate to mark her book as the first Wisconsin novel.

Stronger candidates are two novels written by Juliette Magill Kinzie, who is well known to Wisconsin readers. Her husband was appointed Indian Agent at the Portage in 1830, and the couple lived there for two and a half years. Her memories of that era are beautifully told in her book, *Wau-Bun,* *the Early Day in the Northwest,* first published in 1856 and republished many times since. Following the years at the Portage, they lived in Chicago, and Mrs. Kinzie, besides raising a family, continued her writing. The novel, *Walter Ogilby,* appeared in 1869; *Mark Logan the Bourgeois,* in 1871 (the 1887 edition in Blackshear is a reprint, 342), a year after Mrs. Kinzie's death. The first was set in New York state (not "at Fort Winnebago" as the *Dictionary of Wisconsin Biography* has it, 208); the second, an adventure novel, is set in what was then Michigan territory—in Green Bay, along the Fox River, and at the Portage. The narrative is competently written, though the story, concerning an affluent young man masquerading as a voyageur is derivative. Mrs. Kinzie makes good use of her knowledge of the settings. Is two and half years enough to qualify a writer as a native? We would certainly balk at not calling *Wau-Bun* anything other than a Wisconsin book.

But the strongest candidate for the honor of the first "Wisconsin" novel seems to be the book, *Garangula, the Ongua-Honwa Chief: A Tale of Indian life Among the Mohawks and Onondagas Two Hundred Years Ago.* Published in Milwaukee in 1857, its title page claims that it was written by a citizen of that city. The book is certainly a novel—about 60,000 words in length. Commentary about the book in an article, "Early Wisconsin Imprints," in *Wisconsin Historical Society Proceedings* for 1903 (120–21) reveals nothing further about the author. The subject matter and setting are obviously New York, but in the early days of Dutch settlement. It is, primarily, a love story involving Katrine, "a beautiful, plump, rosy-cheeked, black-eyed" girl, and Diedrich, a stalwart Dutch boy. They are caught up in the border wars, allies of the Mohawk but enemies of the French. Through all the misunderstandings and hair-raising adventures, love finally wins out, and handsome Diedrich in the end marries the beautiful Katrine, and they all live happily ever after. Because of his/her intimate knowledge of the area around Schenectady, the author must have been raised there. So important questions remain: When did he/she write the book? When did he/she move to Wisconsin?

And then there is *Bachelor Ben.* That, too, is set in New York, but in the city. Benjamin Grant, a bachelor of about 30, finds an abandoned babe on his doorstep at midnight. The following day he adopts the little girl, naming her Bertha. Later he befriends a young boy by the name of Harry, takes him under his wing and sends him to school. Of course love develops between the two youngsters, and following college Harry will marry Bertha. Then there are revelations: Bertha and Harry are said to be brother and sister! A few bad moments—but the confusion is finally cleared up. They marry and live happily ever after with Bachelor Ben helping them set up an orphanage in the mansion of his former partner, the real father of Bertha. That was the first, but not the only novel by Ella Giles, later Ruddy. She continued her career in writing, both fiction and poetry, but the date of that first novel is finally too late to stand unchallenged as the first in Wisconsin.

What we have left after this curious—and curiouser—walk-about among the musty pages of the past are six possibilities: *Garangula,* 1857, is the earliest published—if only we knew something definitive about the author. *Walter Ogilby,* 1869, and *Mark Logan,* 1871, were the next earliest, and though it is a book for boys, we can't just ignore Will Phillips, whose date of publication, 1873, puts it midway among these survivors. *Several Lives,* 1874, is another possibility, but it just barely qualifies as a novel.

Julia shares the publication date of 1875 with *Bachelor Ben,* but like that novel, it is not set in the state, though both Rev. Vahey and Ella Giles are certainly Wisconsin authors. Not one is a perfect candidate.

Garangula should, without question, be cited at the first novel published in Wisconsin, but since it seems likely that its author wrote the story before coming to the state, it cannot be considered the first "Wisconsin" novel. That leaves the novels of Juliette Magill Kinzie, whose ties to Wisconsin were short though strong. Her first novel, *Walter Ogilby,* set elsewhere, does not reveal any ties to the state, and so misses on one of our criteria. But her second novel not only takes place primarily in what would become Wisconsin, but makes vivid use of her actual experiences in the area. *Mark Logan,* then, seems the best and firmest candidate for the honor of being called the first "Wisconsin" novel.

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Deer Reproduction in Wisconsin

Abstract *White-tailed deer* (Odocoileus virginianus) *reproductive information was obtained during 1982–87 from 1,686 does. About two-thirds of all does were pregnant in all regions except the Southern Farmland Region where about three-quarters were pregnant. The incidence of fawn pregnancy ranged from 3% in the Northern Forest Region to 51% in the Southern Farmland Region and appeared to vary with deer density relative to estimates of maximum carrying capacity. Statewide, the number of fetuses per pregnant doe averaged 1.65 ± 0.02 (S.E). Mean litter size of yearlings and adults was generally lower in the forested regions than in the farmland regions. The sex ratio for all fetuses observed was 109 males per 100 females. In utero productivity of does increased with age until 2.5 years old and declined after does reached 8.5 years of age. Estimates of in utero productivity for regional populations ranged from 1.10 fawns per doe in the Northern Forest Region to 1.26 in the Southern Farmland Region and correlated with the percentage of yearlings among does and with antler development of yearling bucks.*

The Wisconsin Department of Natural Resources (WDNR) is responsible for balancing the positive benefits (hunting and non-hunting recreation, economic expenditures, etc.) and negative impacts (deer-vehicle accidents, crop damage, etc.) of Wisconsin's white-tailed deer resource. The WDNR uses regulated harvests to manage deer populations at established population goals. Proper harvest management involves balancing mortality rates with reproduction. However, deer reproductive potential has not been well documented in Wisconsin. Earlier research had limited sample size (Dahlberg and Guettinger 1956:84) or restricted geographic distribution (Hale 1959). Additionally, reproductive rates of white-tailed deer are density-dependent (McCullough 1979), and deer densities in the farmland regions have increased considerably since these earlier studies.

Our objectives were to determine age-specific reproductive rates and fetal sex ratios for the major physiographic regions in the state. Additionally, we compared estimates of the productivity of regional deer populations to several indices that are currently used to monitor deer reproduction.

Physiographic Regions

Wisconsin is divided into over 120 deer management units. For our analyses, deer management units were grouped into 5 physiographic regions based mainly on land use (Figure 1).

Northern Forest Region

This region lies above 45° latitude in the east and 46° in the west. Severe winters (causing significant direct mortality of deer) occur on average once per 3 to 4 years (Kohn 1972, McCaffery 1987). Most units within this region are 75 to 95% deer range (patches > 4 ha [10 acres] of commercial and non-commercial forest land, reverting brushy old fields, plus a 100 m [330 ft] perimeter extending from this permanent cover into agricultural fields [McCaffery 1988, Wisconsin Department of Natural Resources 1994]) and forested mainly with northern hardwoods (mostly *Acer* spp.), aspen (*Populus* spp.), balsam fir (*Abies balsamea*), pines (*Pinus* spp.), and swamp conifers (mostly *Picea mariana, Thuja occidentalis,* and balsam fir) (Spencer et al. 1988). Topography is gently to moderately rolling. Soils include stoney glacial till, pitted outwash sands, and peat.

Deer densities from 1982 to 1987 averaged about 6.7 deer/km^2 (17/mi^2) of deer range, which is close to the established goal of 6.9 (18/mi^2). Winters are the main variable affecting annual variation in carrying capacity in northern Wisconsin. The winter severity index for northern Wisconsin (Creed et al. 1984:256) averaged 62 for the 6 years of the study compared to the long term (1960–89) average index of 68 (Wisconsin Department of Natural Resources 1994:12). Severe conditions for deer occur when the index exceeds 80. Thus, sampling occurred under representative deer densities and winter conditions.

Central Forest Region

This region experiences severe winters for deer an average of once in 6 years (Kubisiak 1979). The primary landuse is forestry and cranberry production, although dairy and truck farming exists on the perimeter of this region. The land is generally flat and is 70 to 88% deer range, which includes open marshes and forests that are mostly oaks (*Quercus* spp.), pines, and aspen. Soils are mainly sands, sandy loams, and shallow peats. Deer populations in the Central Forest Region averaged about 12.3 deer/km^2 (32/mi^2) of deer range during the study, which is somewhat above the goal of 10.6 (28/mi^2).

The Farmland Regions

The Eastern and Western Farmlands, separated by the Central Forest Region, lie above latitude 44° and below the Northern Forest. These regions experience significant winter losses of deer infrequently (1967 and 1979 from 1960–90), whereas winter losses are even less frequent (only 1979 from 1960–90) in the Southern Farmland Region which is between 42°30" and 44° latitude. In all 3 regions, upland forests are mainly central hardwoods (oaks, maples, hickories [*Carya* spp.]) and pines, while

Figure 1. Regions sampled during the 1982–87 deer reproduction survey in Wisconsin. The Northern Region lies north of a line from the cities of Grantsburg to Spooner in the west and from Cornell to Marinette in the east. The Southern Farmland Region lies generally south of a line from LaCrosse to Oshkosh.

wetlands are represented by marshes, shrub-carr, and lowland hardwoods (mainly *Fraxinus* spp. and *Acer saccharinum*). Deer range comprises 25 to 75% of most units, lower in the southeast. Topography varies from gently rolling in the east to steep-walled valleys (mostly 100–200 m [330–660 ft] of relief) in the west. Soils are mainly silt loams and sandy loams. Dairy farming is the primary land use. Overwinter deer populations during this study averaged close to the 1986 goal of about 9 deer/km^2 (23/mi^2) of deer range (Wisconsin Department of Natural Resources 1994:28).

Methods

Wildlife managers throughout the state were provided instructions for collection of reproductive observations from dead deer (mostly road-killed). Observers removed the uterus to determine presence, number, and sex of fetuses. Presence or absence of lactation was noted when fetuses were absent. Observations were restricted to 1 February through 1 June to facilitate determination of sex of fetuses. Observers were instructed to examine deer systematically and not to choose only those that were obviously pregnant.

Ages of deer were initially assigned in the field as fawn, yearling, or adult using a modification of tooth wear and replacement criteria (Severinghaus 1949). The age assigned was the age at the time the deer would have been bred. To confirm field assigned ages and to obtain specific ages of adult does, incisors were collected from each doe, and cementum annuli were counted on thin sections (Low and Cowan 1963, Gilbert 1966, Kuehn 1970). When annuli on tooth sections of young deer were indistinct, the field assigned age was used as suggested by Howe (1980).

In utero productivity of regional populations was estimated by multiplying the estimated proportion of the doe population in each age class by the respective pregnancy rate and fetuses per pregnant doe. The proportion of yearlings and adults for each region was determined using age data obtained from harvested animals (Wisconsin Department of Natural Resources, unpublished data). The proportion of fawns was estimated from summer roadside observations of fawns and does in the forested regions, an assumed fawn:doe ratio of 1.2 for the farmland regions, and the observed fetal sex ratio of 109 males per 100 females. The resulting age distribution of females ranged from 28% fawns, 20% yearlings, and 52% adults in the Northern Forest Region to 36% fawns, 27% yearlings, and 37% adults in the Southern Farmland. Estimates of in utero herd productivity were compared to 3 potential indices of reproductive performance: (1) summer roadside observations of fawns per doe (Rusch 1986), (2) antler development of yearling bucks (percentage with forked antlers), and (3) the percentage of yearlings among does $\geq$ 1.5 years old (Wisconsin Department of Natural Resources, unpublished data).

Regional pregnancy rates of fawns were compared to regional deer densities relative to estimated maximum deer carrying capacity. Estimates of regional deer carrying capacity were based on observed rates of population increase (post-harvest to subsequent preharvest or Lambda_2) relative to deer population size (Keith 1988; Wisconsin Department of Natural Resources 1994, 1995); i.e., $K = D/2\text{-}L$ where D is the 13-year (1981–93) mean deer density, L is the mean (1981–93) Lambda_2, and 2 was assumed to be the maximum instantaneous rate of increase for any region (McCullough 1979, Keith 1988, McCaffery 1989, Wisconsin Department of Natural Resources 1995: Appendix C).

We used two-way ANOVA to test for age and region effects on mean litter size and made multiple-comparisons with the Duncan's Multiple Range Test. Because litter size is count data, we used a square root transformation (Snedecor and Cochran 1967). These procedures were also used to test for effects of doe age on in utero productivity. Log-linear analyses of three-way contingency tables and chi-square analysis of two-way contingency tables were used to examine the effect of age and region on pregnancy rate. The relationship of pregnancy rate and relative population density was assessed with Spearman rank correlation as were the relationships of estimated herd productivity with the 3 indices of reproduction. Fetal sex ratios were tested for deviation from a 1:1 ratio using a chi-square goodness of fit test, and chi-square contingency tables were used to compare fetal sex ratios among age classes and litter size.

Results

During 1982–87, 1,686 does and 1,895 fetuses were examined. Though not specifically solicited, no observers reported discovering mummified or decaying fetuses. Over 94% of the deer were killed by vehicles on roads. Although samples were sought throughout the state, almost three-fourths of the total sample came from farmland regions (Table 1) because of the high frequency of roadkills there.

Pregnancy Rate

Pregnancy rates differed among age classes in all 5 regions (χ^2 = 68.01-215.12, 2 df, P = 0.001), much lower for fawns than for yearlings and adults (Table 1). Among yearlings and adults, the effect of age was consistent among regions (χ^2 = 1.42, 4 df, P = 0.84), lower for yearlings than adults (χ^2 = 23.71, 1 df, P < 0.001).

The effect of region on pregnancy rate differed among age classes (χ^2 = 31.92, 8 df, P < 0.001). Pregnancy rate did not differ among regions for adults (χ^2 = 2.22, 4 df, P = 0.70) or yearlings (χ^2 = 3.56, 4 df, P = 0.47). However, pregnancy rate of fawns differed among regions (χ^2 = 85.41, 4 df, P = 0.001); lowest in the Northern Forest, intermediate in the Central Forest and Eastern and Western Farmland regions, and highest in the Southern Farmland. Regional fawn pregnancy rate was negatively correlated (r = -1.00, n = 5, P < 0.001) with relative

Table 1. In utero productivity of female white-tailed deer by age class (when bred) for 5 regions of Wisconsin, 1982–87. Values shown ±1 standard error.

Region	Age Class	No. of Does	Percent Pregnant	No. of Fetuses	Fetuses per Pregnancy	Fetuses per Doe
Northern	Fawns	79	3 ± 3	4	2.00 ± 0	0.05
Forest	Yearl	58	81 ± 5	65	1.38 ± 0.07	1.12
	Adult	163	95 ± 2	268	1.75 ± 0.04	1.64
Central	Fawns	42	17 ± 6	8	1.14 ± 0.14	0.19
Forest	Yearl	34	85 ± 6	37	1.28 ± 0.08	1.09
	Adult	45	96 ± 3	80	1.86 ± 0.17	1.78
Western	Fawns	182	29 ± 3	62	1.17 ± 0.05	0.34
Farmland	Yearl	106	86 ± 3	148	1.66 ± 0.05	1.40
	Adult	135	96 ± 2	249	1.95 ± 0.04	1.84
Eastern	Fawns	68	19 ± 5	14	1.08 ± 0.08	0.21
Farmland	Yearl	31	94 ± 4	48	1.66 ± 0.09	1.55
	Adult	74	99 ± 1	143	1.96 ± 0.07	1.93
Southern	Fawns	288	51 ± 3	165	1.15 ± 0.03	0.57
Farmland	Yearl	207	88 ± 2	302	1.66 ± 0.04	1.46
	Adult	172	95 ± 2	302	1.90 ± 0.04	1.76
Statewide		1,684	69	1,895	1.65 ± 0.02	1.13

population density (percent of estimated regional carrying capacity) and positively correlated with regional carrying capacity ($r = 0.90$, n = 5, $P = 0.04$, Table 2).

Mean Litter Size

Among the 1,152 litters examined, 39% contained a single fawn, 57% contained twins, and 3% contained triplets. Only two sets of quadruplets were encountered during the study, both from farmland regions.

Statewide, the mean (± SE) litter size (number of fetuses per pregnant doe) was 1.65 ± 0.02 (Table 1). The effect of region on mean litter size differed among age classes (F = 2.61; 8, 1,136 df; $P = 0.008$). For adult (≥ 2.5 yrs when bred) does, mean litter size varied among regions (F = 3.46; 4, 551 df; $P < 0.008$), lower in the Northern Forest than in the Eastern and Western Farmland regions. Mean litter size of yearlings also differed among regions (F = 6.03; 4, 371; $P < 0.001$), lower in the Northern and Central Forests than in the 3 farmland regions. Because of the low fawn pregnancy rate in the Northern Forest, sample size was too small (n = 2) for reliable estimation of mean litter size. Therefore, we excluded the Northern Forest from the regional comparison. Mean litter size for fawns did not differ among the 4 remaining regions (F = 0.24; 3, 213 df; $P = 0.87$).

Productivity versus age

In utero productivity (fetus/doe, including does that were not pregnant) varied among ages (F = 168.88; 9, 1,653 df; $P < 0.001$), increasing with age for fawns, yearlings, and 2 year old does (Figure 2). Productivity did not differ among 2–8 year old does ($P > 0.05$), but productivity of 9+ year old does was lower than for 3–6 year old does ($P < 0.05$). The oldest doe observed during the present collection was 18 years old and was carrying one fetus.

Fetal Sex ratios

Sex was determined for 1,803 of the 1,895 fetuses examined. The sex ratio was 109 males per 100 females, which was nearly different from 1:1 ($\chi^2 = 3.29$, 1 df, $P = 0.07$). Fetal sex ratios did not vary among doe age class ($\chi^2 = 1.62$, 2 df, $P = 0.45$), litter sizes ($\chi^2 = 1.14$, 3 df, $P = 0.77$), or region ($\chi^2 = 3.16$, 4 df, $P = 0.53$).

Regional Population Productivity

Estimates of in utero productivity for regional populations ranged from 1.10 fawns per doe in the Northern Forest to 1.26 fawns per doe in the Southern Farmland (Table 3) and correlated well with the subsequent percentage of yearlings among does ≥ 1.5 years ($r = 0.97$, n = 5, $P = 0.005$) and the percentage of yearling bucks with forked antlers ($r = 0.90$, n = 5, $P = 0.04$). The percentage of yearling does and the percentage of yearling bucks with forked antlers also were correlated ($r = 0.97$, n = 5, $P = 0.005$, Table 3). However, the mean fawn:doe ratio from roadside observations did not correlate with regional in utero productivity ($P = 0.28$), percent yearling does ($P = 0.22$), or antler forking ($P = 0.19$).

Discussion

Among the reproductive parameters we measured, fawn pregnancy rate showed the strongest regional differences. The low fawn pregnancy rate in the Northern Forest (3%) during our study was similar to that reported for northern Wisconsin by Hale (1959), for northern Michigan by Friedrich and Hill

Table 2. Incidence of fawn pregnancy and recent deer herd status (deer/km^2) relative to estimated maximum average carrying capacity (K) in 5 regions of Wisconsin.

Region	K [a]	Mean Density [b]	Percent K	Percent of fawns Pregnant [c]
Northern forest	10.8	6.7	62	3
Central forest	22.3	12.3	55	17
Western farmland	25.4	7.9	31	29
Eastern farmland	26.2	9.3	35	19
Southern farmland	33.5+	8.7	<25	51

[a] Average (1981–94) biological carrying capacity (K) by zone: K = D/2-Lambda$_2$, where D is the average overwinter deer density (1981–94), 2 is the assumed maximum instantaneous rate of increase for any region, and Lambda$_2$ is the average (1981–94) observed rate of herd increase from postharvest to subsequent preharvest. Note that 2 - Lambda$_2$ = %K/100.

[b] Mean overwinter deer density estimate (1981–87) by region from Wisconsin Deer Database (WDNR 1989).

[c] Percent of fawns pregnant from Table 1.

Table 3. Comparative indices to deer reproduction in the 5 regions of Wisconsin.

Region	Fawns/doe in Regional Population [a]	Roadside Fawn:doe Ratios [b]	Yearling Doe Percent [c]	Percent Forks on Yearl. Bucks [c]
Northern forest	1.10	0.81	28	55
Central forest	1.11	1.15	33	59
Western farmland	1.20	1.11	38	86
Eastern farmland	1.22	0.96	38	85
Southern farmland	1.26	1.21	45	94

[a] In utero productivity of regional population based on age-specific fetuses per doe and age composition of females.

[b] Six-year means (1982-87) of fawns/doe from Summer Deer Observation Survey (McCaffery 1992).

[c] Percent yearlings among does $\geq$1.5 yr. (1983–88) and percent of yearling bucks with forked antlers (1982-87) from WDNR unpublished data.

(1982), and for northern Minnesota by Bill Berg (Minnesota Department of Natural Resources, unpublished data).

We estimated a 17% fawn pregnancy rate in the Central Forest; however, our sample size was relatively small. Prior research in this region found only 3 of 40 fawns (8%) necropsied during late-winters of 1968–72 contained fetuses, and only 3 of 38 yearling does (8%) with corpora albicantia (indicating prior pregnancy) between 1979–84 (John Kubisiak, Wisconsin Department of Natural Resources, unpublished data). Hale (1959) reported 16% fawn breeding in his West Central Area, which included both Central Forest and farmland counties. We retabulated his data for our Central Forest Region, and only 6 of 79 fawns (8%) were bred. Our estimate of fawn pregnancy rate for this region was not statistically different from these earlier estimates (χ^2 = 2.88, 2 df, P = 0.24).

Fawn pregnancy rates were at intermediate levels in the Eastern and Western Farmland and highest in the Southern Farmland Region. The 51% fawn pregnancy rate in the Southern Farmland Region was lower than the 65 to 74% reported for Iowa (Haugen 1975), but similar to southern Minnesota (45%, Ingebrigtsen 1988) and

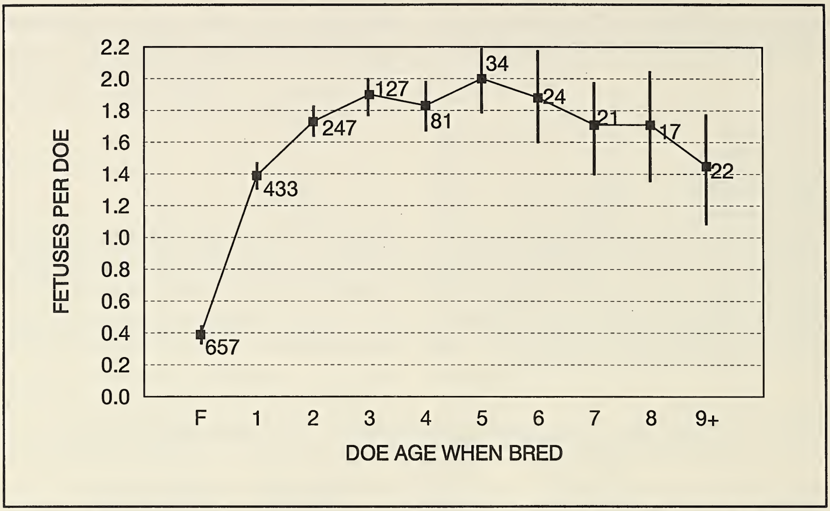

Figure 2. Average fetuses per doe by age class in Wisconsin during 1982–87. Numbers denote total does in sample and vertical bars show 95% confidence limits.

southern Michigan (51%, Friedrich and Hill 1982:Table B, and Verme 1991).

Deer reproductive performance is affected by nutritional condition, which in turn is influenced by density relative to carrying capacity (McCullough 1979 and 1984, Verme 1983, Teer 1984:274). Fertility of the youngest does (fawns and yearlings) is most affected by environmental variables (Hesselton and Jackson 1974). McCullough (1979:61) and Downing and Guynn (1983) indicated that fawn breeding would not generally occur when population densities exceed 60% of carrying capacity.

Local deer carrying capacity is affected by habitat quality, but on a larger scale it is also affected by climate (Strickland et al. 1994:451). The incidence of fawn breeding in Wisconsin increased with decreasing latitude (climatic effect of milder winters and longer growing seasons). Also, the availability of agricultural crops, with high nutrient quality, increases with decreasing latitude. Thus, carrying capacity was much higher in the southern regions of the state. Deer population goals are roughly similar across regions (~7–10 deer/km^2, 18–28/mi^2). As one moved south, the lower deer densities relative to carrying capacity resulted in increased fawn breeding. Regional differences in mean litter size of yearlings and adults also suggested lower reproduction in the forested regions than the farmland regions.

In utero productivity increased with age through 2 years of age, was stable for 2- to 8-year-old does, and then declined (Figure 2). This pattern was very similar to that reported for the eastern United States by Sileo (1966:Figure 2) and a large dataset from Michigan (Friedrich and Hill 1982).

Our statewide fetal sex ratio (109 males/100 females) was similar to other sex ratio estimates for the Lake States, which range from 107 to 119 males/100 females (Mc-

Cullough 1979, Verme 1985, Ingebrigtsen 1988, Paul Friedrich, Michigan Department of Natural Resources, unpublished data). A number of factors have been hypothesized to influence in utero sex ratios including age of the doe (Severinghaus 1984), litter size (Verme 1983), nutritional status (Verme and Ullrey 1984:99, Verme 1985), deer density (McCullough 1979:68), and timing of breeding (Verme and Ozoga 1981). Verme (1983) and Ozoga and Verme (1986) also indicate that primiparous (first pregnancy) does, whether fawns or yearlings, have disproportionately more male offspring. Despite considerable variation in regional carrying capacity and relative population density, we detected no regional variation in fetal sex ratio. Likewise, we found no effect of maternal age or litter size on fetal sex ratio.

The factors that affect sex ratio may vary by region and year, and some factors may be compensatory. But precise and accurate measurement of sex ratio differences requires huge sample sizes. Following their review of the literature, Woolf and Harder (1979) concluded that many observed departures from a near 1:1 ratio may be "mere localized aberrations." Based on our findings and other research in the region, it seems reasonable to believe that the fetal sex ratio tends to favor males in Wisconsin.

Despite the large regional differences in some age-specific reproductive parameters, estimates of population productivity (fawns/all does) were relatively similar among regions ranging only from 1.10 fawns/doe in the Northern Forest Region to 1.26 in the Southern Farmland Region. This similarity was caused by the higher proportion of fawn and yearling does in the population, which produce at lower rates than adults, in the South. Although population productivity was relatively similar among regions, southern herds had a much higher rate of population increase (mean Lambda$_2$ of 1.72 for the Southern Farmland Region vs. 1.33 for the Northern Forest Region when herds are at goals [Wisconsin Department of Natural Resources 1995:191–92]). This was due in part to the higher proportions of does in the population in the South as a result of higher harvest rates of bucks. In addition, recruitment of fawns to the fall population is a function of both reproduction and neonatal survival. Neonatal survival is likely lower in the North due to inadequate maternal nutrition (Verme 1977).

Regional estimates of population productivity were strongly correlated with the percentage of yearlings among does, which is routinely measured in harvested samples. However, variable over-winter mortality associated with winter severity may limit the usefulness of yearling age composition for evaluating annual variation in fawn production, especially in the forested regions. Antler development of yearling bucks has been demonstrated to correlate with production in New York (Severinghaus and Moen 1983) and was significantly correlated with both population productivity and yearling age composition of does. Yearling antler development is annually monitored through mandatory registration of harvested deer and shows promise for monitoring annual as well as regional variation in reproduction.

The Wisconsin Department of Natural Resources has collected roadside observations of fawns and does since the early 1960s. Kohn (1976) reported a negative relationship between fawn:doe ratios in the Northern Forest and an index to winter severity. The lack of correlation between roadside fawn:doe ratios and regional population productivity, percentage of yearlings among does, and antler development of yearling bucks in this study raises questions about the usefulness of this index. Additional research should assess the validity of this index of deer reproduction, especially in the farmland regions.

Recently, some have expressed concern about the effect of high adult buck harvest rates on deer social behavior and herd productivity (Miller et al. 1995). Hale (1959) indicated that the annual firearm hunting season in November did not seem to impair pregnancy rates in Wisconsin at the time of his study. Deer populations and adult buck mortality rates in Wisconsin farmland have increased during the past 30 years. The high incidence of pregnancy among farmland does suggests that pregnancy rates are near normal (Harder 1980) despite adult buck mortality rates of 85 to 90% in many units due mostly to late November gun hunting (Wisconsin Department of Natural Resources 1989:IV). The peak of conceptions tends to occur in mid-November prior to Wisconsin's firearm hunt, however much of the fawn breeding occurs during December (Hale 1959) by surviving adult bucks or pubertal buck fawns (L.J. Verme, pers. comm.).

The results of this study have led to two modifications to WDNR's deer population model. First, the fawn sex ratio is now assumed to be 110 males per 100 females statewide rather than the region-specific estimates of 111–135:100, based on harvested samples of fawns that were used prior to 1986. Second, we have suspended the use of annual data from the summer roadside fawn/doe index in farmland regions, using long-term constants instead.

Since these data were collected, deer populations have increased substantially in the Northern Forest and farmland regions (ratio of mean 1994–96 population estimates:mean 1982-87 population estimates = 1.66, 0.93, 1.36, 1.49, and 1.45 for the Northern Forest, Central Forest, Eastern Farmland, Western Farmland, and Southern Farmland, respectively). While we suspect that fawn pregnancy rates have declined in some regions with the increases in deer density, direct measures of deer reproduction (in utero fetal counts) are not available for recent years. Other indices of reproduction (roadside fawn:doe ratios, percentage of yearlings among does, and antler development of yearling bucks) do not show consistent declines that can be attributed to these higher deer densities. But roadside observations and age composition of harvested does combine data from all age classes of does masking the contribution of fawn does. Because yearlings and adults are affected less by nutritional stress than are fawns, these indices are relatively insensitive to changes in density. Additionally, annual variation of all 3 indices in the forested regions is strongly affected by variation in winter severity, which complicates the detection of density-dependent declines in reproduction within these regions (McCullough 1990).

Deer populations during 1994–96 were well above prescribed population goals. Aggressive harvest strategies and back-to-back severe winters (1996 and 1997) in the North have greatly reduced herd levels. We expect that the reproductive rates observed during this study would be representative of populations near goal.

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Black Bear Food Items in Northern Wisconsin

Abstract *We identified 68 black bear* (Ursus americanus) *food items in 967 scats collected during May through August 1976–79. Frequency of occurrence and volume composition indicate that seasonally important foods were grasses (Gramineae), sedges* (Carex *spp.*), *sweet cicely* (Osmorhiza claytonii), *and quaking aspen* (Populus tremuloides) *in May; grasses, sedges, ants (Formicidae), jack-in-the-pulpit* (Arisaema triphyllum), *and sweet cicely in June; ants, tree and shrub fruit, and wild sarsaparilla* (Aralia nudicaulis) *in July; ants and tree and shrub fruit in August. Plants were found in 100% of the scats, insects in 47%, and other animals in 15%. Of 13 forest communities examined, important bear foods appeared to be more abundant in boreal, aspen, wet mesic, and wet communities.*

Black bear food habits have been reported elsewhere in recent studies (Beeman and Pelton 1980, Irwin and Hammond 1985, Rogers 1987, Hellgren and Vaughan 1988, MacHutchon 1989, McClinton et al. 1992, Hellgren 1993, Boileau et al. 1994). Seasonal changes in diets of black bears are related to availability of foods, preference, and physiological needs (Tisch 1961, Landers et al. 1979, Beeman and Pelton 1980). Availability of foods has been reported to influence reproductive success and the localization of activities within home ranges (Rogers 1976, 1987; Lindzey and Meslow 1977; Novick 1979; Beecham 1980; Young 1980). Thus, the identification of principal and alternate food sources is an important aspect of black bear ecology.

This paper is the compilation of 2 studies (Norton 1981, Bertagnoli 1986) designed to identify the important summer (May–August) food items for black bears. The compilation provides the most comprehensive list of black bear foods for

[1] Deceased, June 20, 1993, at age 43 from Lou Gehrig's disease. This paper is dedicated to him and the memory of his sense of humor and his professionalism, especially his contribution to black bear biology.

Wisconsin. The information can be used to help understand differences in bear productivity within the Great Lakes region and to identify potential impacts of forest management activities on bear habitat quality.

Study Area

The 995-km^2 study area was located in western Iron County, Wisconsin, which borders Lake Superior and the Upper Peninsula of Michigan (Figure 1). Kohn (1982) estimated a population of 255 black bears (1 bear/3.9 km^2) in the study area. A series of hills (the Penokee Range) divides the area into northern and southern zones. The northern zone comprises 25% of the study area and has moderately fertile loams and sandy loams (Soil Conservation Service 1972), with forestry and agriculture the major land uses. The southern zone soils are typically clay or sandy loams representing the Gogebic and Wakefield series (Curtis 1959), with forestry and forest-related recreation the major land uses.

Hardwood and coniferous forest types (Curtis 1959) dominate the study area. Forest reconnaissance data from 1978 (Wisconsin Department of Natural Resources files) showed a composition of 43% northern hardwoods, 25% aspen (*Populus* spp.), 21% conifers, and 8% cleared land. Municipalities and lakes comprise 3% of the study area. Dominant tree species include sugar maple *(Acer saccharum),* yellow birch *(Betula lutea),* and American basswood *(Tilia americana)* in the northern hardwood type. Quaking aspen *(Populus tremuloides)* and big-tooth aspen *(P. grandidentata)* constitute the aspen type. Coniferous forests consist of 3 associations: (1) white spruce *(Picea glauca)* and balsam fir *(Abies balsamea)* are dominant in the boreal or upland type; (2) northern white cedar *(Thuja occidentalis)* and balsam fir dominate in the wet-mesic, or swamp conifer type; (3) black spruce *(P. mariana)* and tamarack *(Larix laricina)* dominate in the wet forest type (Curtis 1959). Cleared land includes areas under active cultivation and abandoned farmlands. Both provide sodded openings and a source of domestic apples (*Pyrus* spp.). Common crops are corn, oats, potatoes, and hay. Many streams, lakes, ponds, and bogs occur in the area.

Weather patterns in the area are influenced by Lake Superior. Summer temperatures are lower and precipitation is generally higher than in other areas of the state. Snow cover usually exists from mid-November until mid-April with an annual accumulation of over 279 cm. Length of the growing season is 110–120 days.

Methods

This study was conducted in conjunction with a bear population study by the Wisconsin Department of Natural Resources (Kohn 1982). Food habits were determined by analyzing fresh scats (fecal droppings) collected daily during May through August, 1976–1979. Scats were placed in plastic bags, labeled (date, location), and frozen to maintain color, texture, and aroma of food items.

Laboratory procedures described by Adams (1957) and Korschgen (1969) were used to analyze the scats. Food items were identified by comparing scat fragments with plates in Symonds (1963) and Montgomery (1977), reference materials collected on site, plant keys, and herbarium specimens. Mammal remains were identified with the hair key developed by Adorjan and Kolenosky (1969) and by comparing bone and hair samples with museum specimens. An ocular estimate of the percent composition of solid material in each scat was recorded: trace, 2–5%, 6–15%, 16–50%, 51–75%,

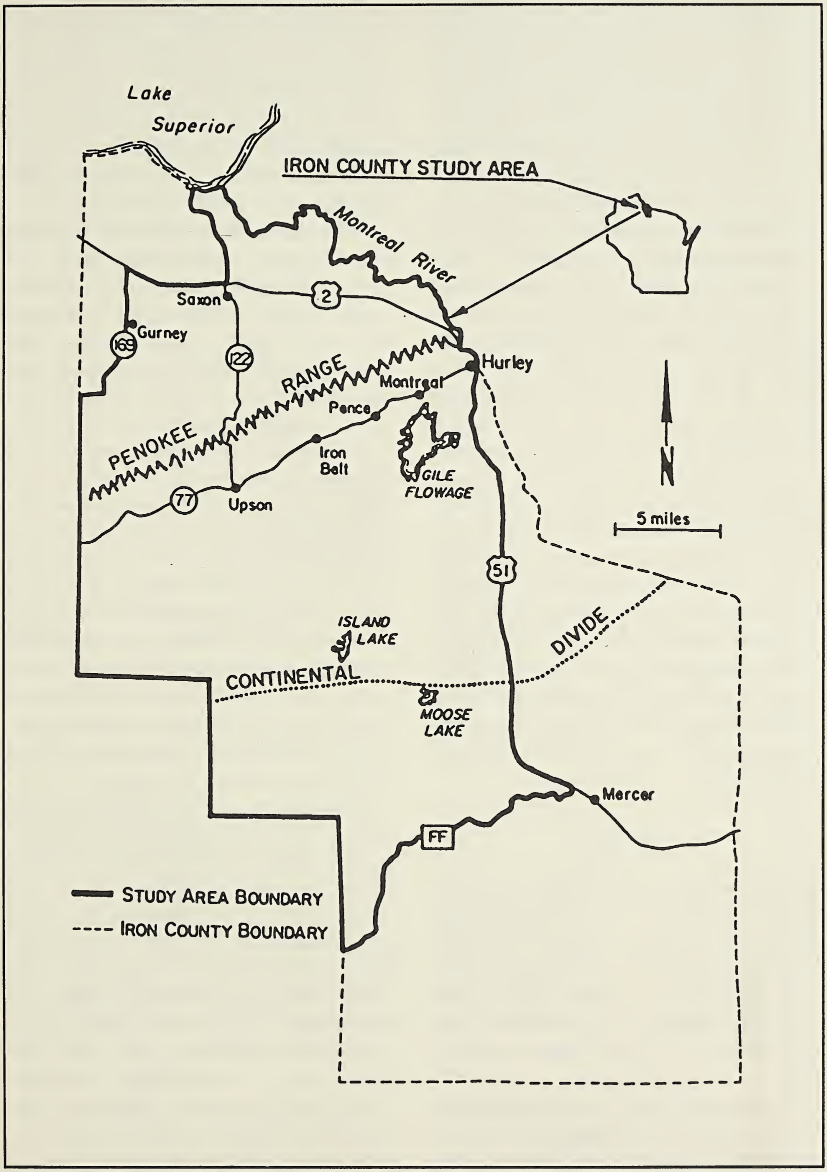

Figure 1. Location and major features of the Iron County study area in Wisconsin.

76–100% (Clark 1957, Tisch 1961, Beeman 1971). Food use was summarized monthly by percent composition and frequency of occurrence in the scats. Forage importance values (frequency of occurrence x percent composition) also were determined for each food item (McCaffery et al. 1974). Percent composition values for all food items eaten each month were compared among all years by using *Z*-tests (Neu et al. 1974).

Availability of bear foods within forest types was estimated by using data from the original field sheets of Curtis (1959) in the Plant Ecology Laboratory, Department of Botany, University of Wisconsin-Madison. The percentage of study plots in which Curtis (1959:79) observed a plant species in each forest community was used to estimate availability of that plant species. Similarities between forest communities relative to availability of plant foods were determined by using indices of similarity (Curtis 1959:83). In 1978 and 1979, the relative importance of a forest community as a source of plant foods for black bears was estimated from the percent occurrence of each plant food found in the community and from the forage importance value (determined by scat analysis) for that food.

Results

Sixty-eight black bear food items were identified from analysis of 967 scats collected during May through August 1976–79. Nineteen percent of the scats were collected in May, 38% in June, 23% in July, and 20% in August. Plants occurred in 100% of the scats, insects in 47%, and other animals in 15%.

Foods of black bears were identified and ranked by their forage importance (FI) values (Table 1). Plant material dominated the diet in frequency and volume, with grasses and sedges having the greatest forage importance value (1,151). Grasses and sedges were combined and identified as 1 food item because of the difficulty in separating families, genera, and species. Of the black bear foods identified from scats, 32 had low (<10) forage importance values. Some unidentifiable material occurred in all scats examined.

Members of the Rosaceae had relatively high forage importance values: apple (*Pyrus malus* and *Pyrus* spp.), raspberry (*Rubus* spp.), cherry (*Prunus* spp.), juneberry (*Amelanchier* spp.). So did blueberry (*Vaccinium* spp.). Excluding fruit, quaking aspen leaves and catkins were the most important tree parts used by black bears in this area.

Colonial insects (mainly ants) were the most important of the animal remains identified. Snowshoe hares *(Lepus americanus)* had the highest forage importance value of all other animal foods. The remains of hares, consisting of small amounts of hair and bone, could have represented scavenging or predation. White-tailed deer *(Odocoileus virginianus)* remains were observed at low levels. The remains consisted of hair and bone chips, the result of scavenging or predation. We observed 12 occurrences of black bear remains in black bear scats.

In all months a variety of foods was eaten, but only a few had high monthly forage importance values (Table 2). The general pattern in food habits for bears in northern Wisconsin was as follows: (1) In May, grasses, sedges, sweet cicely, and aspen catkins and leaves were most important. Ants, skunk cabbage *(Symplocarpus foetidus)*, common dandelion *(Taraxacum officinale)*, cow parsnip *(Heracleum maximum)*, clover (*Trifolium* spp.), hemlock *(Tsuga canadensis)* needles, and cranberries (*Vaccinium* spp.) were important as some of the diet for most bears or most of the diet for some bears. (2) In June, grasses, sedges, ants, jack-in-the pulpit, and sweet cicely were most important. Skunk cabbage, common dandelion, and aspen leaves and catkins were important as some of the diet for most bears or most of the diet for some bears. (3) The diets of black bears seemed to be the most diverse in July. Ants, tree and shrub fruits (especially Rosaceae: *Rubus* spp., blueberry [*Vaccinium* spp.], wild sarsaparilla, and apple) and jack-in-the-pulpit were most important. Common dandelion, grasses, sedges, and sweet cicely were important as some of the diet for most bears. (4) In August, ants, tree and shrub fruit (especially *Rubus* spp., cherry, mountain holly *[Nemopanthus mucronatus]*, red-osier dogwood *[Cornus stolonifera]*, and apple) were most important. Grasses, sedges, clover, wild sarsaparilla, jack-in-the-pulpit, and bees (Vespidae) were important as some of the diet for most bears or most of the diet for some bears. The occurrence of Vespidae in scats probably indicates the use of honey and honey bees *(Apis mellifera)*, both wild and commercial, in the diet. In Wisconsin, bears often raid apiaries, resulting in nuisance complaints.

Type and pattern of food use were similar during all 4 years, but differences ($P < 0.05$) were noted in the number of occurrences of some foods. The use of apples, blueberries, blackberries (*Rubus allegheniensis*), and juneberries and the farm crops of corn and oats reflected annual differences in their availability. Jack-in-the-pulpit, skunk cabbage, red-osier dogwood, sweet cicely, wild sarsaparilla, and common dandelion were important in the diet in 1976 and 1977, but were not eaten in 1978 and 1979. Only 10 of the 68 bear food items were present all 4 years.

Of those foods common all years, ants ($Z = -5.19$), buds ($Z = -11.45$), blackberries ($Z = -2.87$), clover ($Z = -3.95$), grasses ($Z = -8.41$), juneberries, raspberries, and snowshoe hares occurred more ($P < 0.05$) in 1978 and 1979 than in 1976 and 1977. Occurrences of aspen catkins ($Z = 2.26$), cherries ($Z = 4.08$), and mountain holly ($Z = 2.60$) were greater ($P < 0.05$) in 1976 and 1977 than in 1978 and 1979.

Plant foods used by black bears were present in every forest community of the study area in 1978 and 1979 (Table 3). With > 26 food items in wet mesic, > 25 in boreal, and > 25 in aspen communities, these communities appeared to contain the greatest number of plant foods and have the greatest community forage importance values (Table 4). Most (> 65%) of the plant foods in the wet mesic, boreal, and aspen communities occurred in > 25% of the stands examined by Curtis (1959).

Although sample sizes were low, differences ($P < 0.05$, 12 df) existed between availability and use of grasses ($\chi^2 = 79.8$), red-osier dogwood ($\chi^2 = 64.8$), sweet cicely ($\chi^2 = 134.1$), raspberry ($\chi^2 = 102.2$), cherry ($\chi^2 = 75.0$), wild sarsaparilla ($\chi^2 = 183.2$), juneberry ($\chi^2 = 84.2$), aspen leaves ($\chi^2 = 76.8$), blueberry ($\chi^2 = 115.7$), clover ($\chi^2 = 69.9$), water arum ($\chi^2 = 63.2$), blackberry ($\chi^2 = 74.7$), moss (Lycopodiales, $\chi^2 = 137.2$), and gooseberry (*Ribes* spp., $\chi^2 = 75.0$) throughout the 13 forest communities. A chi-square test of frequency indicated a positive relationship ($P < 0.05$) between availability of plant foods and use by black bears in the forest communities studied (Table 5). Dry mesic, mesic, wet mesic, wet, aspen, sedge, and bracken communities provided more ($P < .05$) grasses than other communities. Similarly, wet mesic, wet, aspen, and alder communities provided more ($P < 0.05$) red-osier dogwood than other communities. In general, of the 13 forest communities examined, important bear foods appeared to be more abundant in boreal, aspen, wet mesic, and wet communities.

Discussion

Plants and insects were the most important bear food items found in this study. The importance of plant material for black bears has long been recognized (Cottam et al. 1939). The relatively small number of important plant foods indicates that black bears rely on certain key foods to meet their nutritional needs (Rogers 1976, 1987).

Grasses and sedges, sweet cicely, and the catkins and leaves of quaking aspen were the most important bear food items from the time of den emergence until 30 June. Early fruiting shrubs (*Ribes* spp. and *Vaccinium* spp.) also were important food items during this period.

Ants (Formicidae) had the highest forage importance value of all food items in July and were important in all 4 months. Fruits of raspberry, blueberries, and wild sarsaparilla also were important food items in July. Although jack-in-the-pulpit is mildly toxic (Gleason and Cronquist 1963), it too was eaten often in July.

Tree fruits (*Prunus* spp. and *Pyrus* spp.) constituted a major portion of the August diet. Tree fruits were dominated by a single species—black cherry *(Prunus serotina)*. When abundant, black cherries were preferred to other fruits. Bears foraged for black cherries on the forest floor or climbed the trees for them. Branches of fruiting trees along opening edges and roadsides often were broken by bears. Preference for black cherries might be responsible for the reduced frequency of shrub fruits in the diet. Bears in the nonagricultural portion of the study area appeared to supplement their diet with mountain holly when black cherries were not abundant.

Domestic oats also provided an alternate food source. Farmers in the study area reported that bear damage to oats crops was highest when black cherries and blueberries were scarce; damage was nonexistent or low when the fruits were abundant.

White-tailed deer were not an important food item of bears during this study. But Anderson and Fleming (1994) reported that 7 of 12 radio-tagged fawns killed by predators in their study area (only 40 km west of ours) were killed by bears. They thought that most of the bear predation was due to chance encounters with fawns less than 2 weeks old, but noted that bears were known to be purposely hunting fawns on several occasions.

Most of the principal foods used by bears in this study were produced by shade intolerant plants as defined by Curtis (1959). In Wisconsin, these are abundant in grassy forest openings, road rights-of-way, recent cutovers, canopy gaps, natural wetlands, pine openings, and the aspen and aspen-balsam forest types. In addition, all of the rotting logs in the sodded forest openings on the study areas were visited by bears in search of insects. Except for sweet cicely and a few mature black cherry trees, northern hardwood stands provided limited amounts of bear food items in the study area.

Wisconsin's black bears are among the largest and most productive in the country (Reneau and Reneau 1993, Kessler 1994). This undoubtedly reflects the quality of the current habitat.

Table 1. Annual black bear food habits in northern Wisconsin as determined from 967 scats collected during 4 summers (May, June, July, August) 1976–79.

	1976			1977			1978			1979			Average		
Food Item[a]	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*
Monocots															
Gramineae and Cyperaceae	41.2	25.2	1038	48.4	19.0	920	71.6	12.0	859	73.7	22.0	1621	58.7	19.6	1151
Arisaema triphyllum	16.2	36.7	595	11.0	31.5	347	0.0	0.0	0	0.0	0.0	0	6.8	17.1	116
Symplocarpus foetidus	4.0	46.0	184	3.1	27.2	84	0.0	0.0	0	0.0	0.0	0	1.8	18.3	33
Zea mays	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.3	22.0	51	0.6	5.5	3
Alisma spp.	2.1	18.4	39	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	4.6	2
Acorus calamus	0.8	28.0	22	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	7.0	1
Juncus spp.	0.5	49.1	25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	12.3	1
Avena sativa[b]	—	—	—	—	—	—	0.5	3.0	2	0.0	0.0	0	0.1	0.8	<1
Equisetum spp.	0.5	3.0	2	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	0.8	<1
Unidentified monocots	1.6	19.7	32	3.2	19.2	61	3.4	1.0	3	5.3	1.0	5	3.4	10.2	35
Dicots															
Osmorhiza claytonii	19.7	24.8	489	16.2	18.3	297	13.2	11.0	145	15.8	22.0	348	16.2	19.0	308
Trifolium spp.	4.5	13.6	61	7.5	13.2	99	13.2	2.0	26	12.8	9.0	115	9.5	9.5	90
Taraxacum officinale	9.6	17.2	165	16.5	21.5	355	0.0	0.0	0	0.0	0.0	0	6.5	9.7	63
Fragaria spp.	0.3	5.0	2	0.8	10.0	8	1.5	1.0	2	1.5	45.0	68	1.0	15.3	15
Heracleum maximum	1.8	17.7	32	4.0	18.2	73	0.0	0.0	0	0.0	0.0	0	1.5	9.0	14
Calla palustris	0.0	0.0	0	0.0	0.0	0	25.0	2.0	50	27.8	2.0	56	13.2	1.0	13
Unidentified Umbelliferae	1.6	5.0	8	11.9	6.1	73	0.0	0.0	0	0.0	0.0	0	3.4	2.8	10
Hieracium spp.	1.1	11.0	12	0.8	10.3	8	0.0	0.0	0	0.0	0.0	0	0.5	5.3	3
Lycopodium spp.	0.0	0.0	0	0.0	0.0	0	9.8	1.0	10	9.0	1.0	9	4.7	0.5	2
Urtica spp.	0.0	0.0	0	0.5	30.0	15	0.0	0.0	0	0.0	0.0	0	0.1	7.5	1
Polygonum cilinode	0.0	0.0	0	1.2	18.2	22	0.0	0.0	0	0.0	0.0	0	0.3	4.6	1
Unidentified Compositae	0.0	0.0	0	0.0	0.0	0	2.0	1.0	2	4.5	1.0	5	1.6	0.5	1
Viola spp.	0.0	0.0	0	0.4	25.0	10	0.0	0.0	0	0.0	0.0	0	0.1	6.3	1
Unidentified ferns	0.0	0.0	0	0.0	0.0	0	1.5	1.0	2	3.0	1.0	3	1.1	0.5	1
Potentilla spp.	0.3	5.0	2	0.4	1.0	1	0.0	0.0	0	0.0	0.0	0	0.2	1.5	<1
Sonchus spp.	0.2	1.0	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	0.3	<1
Cornus canadensis	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	1.0	2	0.4	0.3	<1
Lactuca spp.	0.0	0.0	0	0.0	0.0	0	1.0	1.0	1	1.5	1.0	2	0.6	0.5	<1
Unidentified dicots	4.1	27.0	111	5.5	28.1	155	9.8	1.0	10	6.8	1.0	7	6.6	14.3	94

Table 1, continued.

Food Item[a]	1976 F	1976 C	1976 FI	1977 F	1977 C	1977 FI	1978 F	1978 C	1978 FI	1979 F	1979 C	1979 FI	Average F	Average C	Average FI
Tree fruit															
Prunus serotina [c]	12.2	45.0	549	30.3	60.4	1830	0.0	0.0	0	0.0	0.0	0	10.6	26.4	280
Pyrus spp.[d]	5.8	49.3	286	2.4	38.0	91	0.0	0.0	0	0.0	0.0	0	2.1	21.8	46
Pyrus malus [d]	0.0	0.0	0	0.0	0.0	0	9.8	40.0	392	3.8	7.0	27	3.4	11.8	40
Prunus spp.[c]	0.0	0.0	0	0.0	0.0	0	13.2	18.0	238	8.3	8.0	66	5.4	6.5	35
Sorbus americana	0.8	37.2	30	4.7	36.5	172	0.0	0.0	0	0.0	0.0	0	1.4	18.4	26
Prunus virginiana [c]	3.2	33.4	107	1.2	6.6	8	0.0	0.0	0	0.0	0.0	0	1.1	10.0	11
Pyrus coronaria [d]	0.0	0.0	0	0.0	0.0	0	0.5	1.0	1	0.0	0.0	0	0.1	0.3	<1
Shrub fruit															
Rubus spp. (raspberry)	8.2	1.1	9	2.8	41.6	117	18.6	11.0	205	21.8	12.0	262	12.9	16.4	212
Aralia nudicaulis	20.0	14.2	284	5.9	13.5	80	15.7	11.0	173	18.8	5.0	94	15.1	10.9	165
Vaccinium spp. (blueberry)	8.0	30.9	247	4.7	24.2	114	12.8	8.0	102	3.0	2.0	6	7.1	16.3	116
Cornus stolonifera	0.0	0.0	0	0.0	0.0	0	13.2	31.0	409	6.8	24.0	163	5.0	13.8	69
Nemopanthus mucronatus	7.4	35.9	266	0.8	48.5	39	2.5	5.0	13	0.0	0.0	0	2.7	22.4	60
Ribes spp.	3.2	12.2	39	2.0	45.7	91	5.4	1.0	5	3.0	1.0	3	3.4	15.0	51
Amelanchier spp.	0.3	5.0	2	0.0	0.0	0	6.4	1.0	6	17.3	18.0	311	6.0	6.0	36
Vaccinium spp. (cranberry)	1.9	10.4	20	3.1	12.3	38	1.0	1.0	1	5.3	1.0	5	2.8	6.2	17
Rubus allegheniensis	2.1	57.1	120	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	14.3	7
Viburnum spp.	0.0	0.0	0	1.2	25.3	30	1.5	1.0	2	0.8	1.0	1	0.9	6.8	6
Rubus spp.	0.0	0.0	0	0.0	0.0	0	6.9	11.0	76	0.0	0.0	0	1.7	2.8	5
Sambucus pubens	0.3	5.0	2	0.0	0.0	0	2.0	2.0	4	4.5	2.0	9	1.7	2.3	4
Vitis spp.	0.0	0.0	0	0.4	25.0	10	0.0	0.0	0	0.0	0.0	0	0.1	6.3	1
Cornus alternifolia	0.0	0.0	0	0.0	0.0	0	1.0	2.0	2	0.8	1.0	1	0.5	0.8	<1
Unidentified	3.5	13.3	47	2.4	21.6	52	4.9	3.0	15	17.3	7.0	121	7.0	11.2	78
Other tree and shrub parts															
Populus tremuloides (leaves)	2.1	18.0	38	7.1	37.0	263	4.9	1.0	4.9	5.3	42	223	4.9	24.5	120
Populus tremuloides (catkins)	7.2	30.6	220	2.0	39.0	78	0.5	1.0	1	4.5	30.0	135	3.6	25.2	91
Thuja occidentalis (leaves)	1.8	4.4	8	0.0	0.0	0	0.5	1.0	1	6.1	52.0	317	2.1	14.4	30
Tsuga canadensis (needles)	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.3	51.0	117	0.6	12.8	8
Rhamnus alnifolia	0.0	0.0	0	0.0	0.0	0	3.9	5.0	20	1.5	12.0	18	1.4	4.3	6
Ulmus americana (seeds)	0.0	0.0	0	3.1	21.0	65	0.0	0.0	0	0.0	0.0	0	0.8	5.3	4
Tsuga canadensis (cones)	0.3	75.0	23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	18.8	2
Corylus spp.	0.0	0.0	0	0.0	0.0	0	1.5	1.0	2	3.8	1:0	4	1.3	0.5	1
Pinaceae (cone scales)	0.0	0.0	0	0.0	0.0	0	2.5	1.0	3	3.0	1.0	3	1.4	0.5	1

Table 1, continued.

Food Item[a]	1976 F	1976 C	1976 FI	1977 F	1977 C	1977 FI	1978 F	1978 C	1978 FI	1979 F	1979 C	1979 FI	Average F	Average C	Average FI
Corylus spp.	0.0	0.0	0	0.0	0.0	0	1.5	1.0	2	3.8	1.0	4	1.3	0.5	1
Pinaceae (cone scales)	0.0	0.0	0	0.0	0.0	0	2.5	1.0	3	3.0	1.0	3	1.4	0.5	1
Thuja occidentalis (cones)	0.0	0.0	0	0.0	0.0	0	0.5	1.0	1	0.0	0.0	0	0.1	0.3	<1
Picea glauca (needles)	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.8	1.0	1	0.2	0.3	<1
Abies balsamea (needles)	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.8	1.0	4	1.0	0.3	<1
Unidentified buds	0.5	3.0	2	0.0	0.0	0	19.6	1.0	20	21.8	3.0	65	7.3	1.9	14
Unidentified plants	32.7	17.1	559	41.4	14.6	604	85.8	34.0	2917	75.9	25.0	1898	59.0	22.7	1339
Insects															
Formicidae	36.2	11.1	402	37.5	14.0	525	52.0	3.0	156	57.1	9.0	514	45.7	9.3	425
Vespidae	7.2	7.8	56	1.2	11.0	13	2.5	1.0	3	3.8	9.0	34	3.7	7.2	27
Orthoptera (grasshopper)	0.5	30.0	15	0.3	5.0	2	0.0	0.0	0	0.0	0.0	0	0.2	8.8	2
Bombidae	0.0	0.0	0	0.0	0.0	0	1.0	1.0	1	4.5	1.0	5	1.4	0.5	1
Coleoptera	0.3	1.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	0.3	<1
Unindentified	0.9	3.9	4	0.4	10.0	4	1.0	1.0	1	1.5	1.0	2	1.0	4.0	4
Mammals															
Lepus americanus	0.3	45.0	14	0.4	20.0	8	7.8	1.0	8	4.5	1.0	5	3.3	16.8	55
Ursus americanus	0.0	0.0	0	5.0	59.5	298	3.4	1.0	3	1.5	1.0	2	2.5	15.4	39
Procyon lotor	0.5	38.3	19	0.4	35.0	14	0.0	0.0	0	0.0	0.0	0	0.2	18.3	4
Other animal	0.0	0.0	0	0.0	0.0	0	12.3	1.0	12	18.8	1.0	19	7.8	0.5	4
Castor canadensis	0.3	10.0	3	1.2	9.1	11	0.0	0.0	0	0.0	0.0	0	0.4	4.8	2
Marmota monax	0.5	8.0	4	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	2.0	<1
Ondatra zibethicus	0.3	5.0	2	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	1.3	<1
Odocoileus virginianus	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.0	1.0	6	1.5	0.3	<1
Unidentified	3.7	41.0	152	2.0	28.2	56	3.4	1.0	3	6.8	1.0	7	4.0	17.8	71
Total plants	98.9	69.1	6834	98.4	67.5	6642	100.0	53.0	5300	100.0	57.0	5700	99.3	61.7	6127
Total insects	43.1	10.7	461	39.0	13.9	542	54.9	3.0	165	58.6	9.0	527	48.9	9.2	450
Total mammals	6.1	34.0	207	5.2	33.0	172	0.0	0.0	0	0.0	0.0	0	2.8	16.8	47
Birds	1.9	3.9	7	0.0	0.0	0	0.0	0.0	0	1.5	1.0	2	0.9	1.2	1
Fish	0.3	2.0	1	0.0	0.0	0	1.0	1.0	1	0.0	0.0	0	0.3	0.8	<1
Debris and fine materials	95.5	17.9	1709	97.6	18.4	1796	100.0	36.0	3600	100.0	11.0	1100	97.6	20.4	1991

[a] F = % frequency, C = % volume composition, FI = forage importance value (FI = F X C).

[b] Domestic oats was present all 4 years, but included with grasses in 1976 and 1977.

[c] In 1976 and 1977, 2 species of *Prunus* were identified; in 1978 and 1979, these were combined as *Prunus* spp.

[d] In 1978 and 1979, 2 species of *Pyrus* were identified; in 1976 and 1977, these were combined as *Pyrus* spp.

Table 2. Monthly black bear food habits[a] in northern Wisconsin as determined from 967 scats collected during 4 summers, 1976–1979.

	May			June			July			August		
Food Item	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*
Monocots												
Gramineae and Cyperaceae	88.5	37.0	3275	62.0	10.0	620	37.0	6.0	222	30.0	9.0	270
Symplocarpus foetidus	5.5	24.0	132	3.2	62.0	198	0.0	0.0	0	0.0	0.0	0
Arisaema triphyllum	3.7	12.0	44	14.0	40.0	560	14.0	30.0	420	4.2	37.0	155
Juncus spp.	0.4	99.0	40	0.0	0.0	0	4.4	1.0	4	0.0	0.0	0
Acornus calamus	1.4	2.8	4	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Equisetum spp.	1.0	3.0	3	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Alisma spp.	0.0	0.0	0	2.5	21.0	53	4.4	1.0	4	0.0	0.0	0
Zea mays	0.0	0.0	0	3.0	1.0	3	0.8	32.0	26	0.0	0.0	0
Avena sativa[b]	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	3.0	1
Unidentified monocots	4.6	8.4	39	1.4	25.7	36	7.0	34.5	242	3.0	14.0	42
Dicots												
Osmorhiza claytonii	32.2	23.3	750	23.0	20.0	460	10.0	15.3	153	2.5	23.3	58
Taraxacum officinale	3.6	30.0	108	8.0	22.0	176	16.0	21.0	336	4.6	12.0	55
Heracleum maximum	5.0	20.0	100	0.3	1.0	<1	1.3	22.0	29	0.8	10.5	8
Trifolium spp.	8.7	9.5	83	9.0	5.0	45	7.7	2.4	19	7.5	17.0	128
Calla palustris	3.2	1.0	3	14.3	2.0	29	7.7	3.0	23	5.4	1.0	5
Polygonum cilinode	0.4	5.0	2	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Fragaria spp.	0.0	0.0	0	1.4	2.0	3	1.7	25.0	43	0.0	0.0	0
Hieracium spp.	0.4	1.0	<1	0.0	0.0	0	1.7	15.0	26	0.4	5.0	2
Urtica spp.	0.0	0.0	0	0.4	30.0	12	0.0	0.0	0	0.0	0.0	0
Viola spp.	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	25.0	10
Sonchus spp.	0.0	0.0	0	3.1	1.0	3	0.0	0.0	0	0.0	0.0	0
Potentilla spp.	0.0	0.0	0	0.7	3.0	2	0.0	0.0	0	0.0	0.0	0
Lactuca sp.	0.0	0.0	0	0.0	0.0	0	1.3	1.0	1	0.4	1.0	<1
Cornus canadensis	0.0	0.0	0	0.0	0.0	0	0.4	1.0	<1	0.4	1.0	<1
Unidentified Umbelliferae	0.9	7.5	7	2.1	5.0	11	0.8	8.0	6	0.0	0.0	0
Unidentifed Compositae	0.0	0.0	0	0.7	1.0	1	0.8	1.0	1	2.5	1.0	3
Lycopodiales	1.4	1.0	1	5.0	1.0	5	4.7	1.0	5	2.1	1.0	2
Unidentified ferns	0.0	0.0	0	0.7	1.0	1	1.7	1.0	2	0.4	1.0	<1
Unidentified dicots	3.2	15.6	50	11.3	14.0	158	6.2	15.0	93	2.5	13.0	33

Table 2, continued.

Food Item	May			June			July			August		
	F	C	FI	F	C	FI	F	C	FI	F	C	FI
Tree fruit												
Prunus serotina [c]	0.0	0.0	0	0.7	1.0	1	5.1	17.0	87	45.4	17.5	795
Pyrus malus [d]	0.4	1.0	<1	0.3	1.0	<1	0.8	1.0	1	8.7	40.0	348
Prunus spp. [c]	0.0	0.0	0	0.0	0.0	0	2.1	1.0	2	13.7	12.0	164
Prunus virginiana [c]	0.0	0.0	0	0.0	0.0	0	4.0	15.0	60	2.5	47.5	119
Pyrus spp. [d]	1.4	23.0	32	0.0	0.0	0	5.2	62.0	322	0.8	40.0	32
Sorbus americana	0.0	0.0	0	0.7	1.0	1	4.7	19.0	89	0.8	40.0	32
Pyrus coronaria [d]	0.004	1.0	<1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Shrub fruit												
Rubus spp. (raspberry)	0.0	0.0	0	2.2	1.0	2	22.4	26.5	594	19.6	46.0	902
Nemopanthus mucronatus	0.0	0.0	0	0.3	1.0	<1	2.1	17.0	36	12.0	36.0	432
Cornus stolonifera	0.0	0.0	0	0.0	0.0	0	3.4	2.0	7	11.7	32.0	374
Rubus spp.	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	16.0	11.0	176
Aralia nudicaulis	0.0	0.0	0	4.0	4.0	16	40.0	13.0	520	13.3	11.0	146
Vaccinium spp. (blueberry)	0.0	0.0	0	0.7	1.0	1	23.3	23.4	545	6.6	11.0	73
Amelanchier laevis	0.0	0.0	0	1.0	2.0	2	7.7	18.0	139	6.6	7.0	46
Rubus allegheniensis	0.0	0.0	0	0.3	4.0	1	0.8	14.3	11	2.1	20.0	42
Ribes spp.	0.0	0.0	0	2.5	27.0	68	7.7	8.0	62	3.0	9.4	28
Vitis sp.	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	25.0	10
Viburnum sp.	0.0	0.0	0	0.0	0.0	0	1.3	20.0	26	1.6	6.0	10
Cornus alternifolia	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	2.0	2
Vaccinium spp. (cranberry)	3.2	14.0	45	4.0	7.0	28	4.3	1.0	4	0.8	1.0	1
Sambucus pubens	0.0	0.0	0	0.7	3.0	2	3.4	1.2	4	0.4	1.0	<1
Unidentified	0.4	1.0	<1	4.0	1.4	6	7.3	15.0	110	4.6	6.0	28
Other tree and shrub parts												
Populus tremuloides (catkins)	16.1	28.0	451	2.2	39.0	86	0.0	0.0	0	0.0	0.0	0
Populus tremuloides (leaves)	12.4	30.0	372	5.4	22.0	119	0.0	0.0	0	0.0	0.0	0
Ulmus americana (seeds)	3.7	21.0	78	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Tsuga canadensis (needles)	1.4	51.0	71	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Rhamnus alnifolia	0.0	0.0	0	0.0	0.0	0	2.2	7.0	15	1.9	2.0	4
Thuja occidentalis (leaves)	6.5	3.9	25	1.8	1.0	2	0.0	0.0	0	0.0	0.0	0
Abies balsamea (needles)	1.4	1.0	1	0.7	1.0	1	0.0	0.0	0	0.0	0.0	0
Picea glauca (needles)	0.4	1.0	<1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0

Table 2, continued.

	May			June			July			August		
Food Item	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*	*F*	*C*	*FI*
Thuja occidentalis (cones)	0.0	0.0	0	0.3	1.0	<1	0.0	0.0	0	0.0	0.0	0
Tsuga canadensis (cones)	0.0	0.0	0	0.3	1.0	<1	0.0	0.0	0	0.0	0.0	0
Corylus spp.	0.0	0.0	0	0.4	1.0	<1	0.9	1.0	1	2.0	1.0	2
Pinaceae (cone scale)	1.4	1.0	1	1.8	1.0	2	0.4	1.0	<1	0.0	0.0	0
Unidentified buds	9.7	1.0	10	12.6	2.0	25	8.6	1.0	9	1.7	1.0	2
Insects												
Formicidae	30.0	6.0	180	59.3	11.0	652	69.0	9.4	649	22.0	67.0	1474
Vespidae	0.9	1.0	1	0.3	1.0	<1	2.1	2.0	4	13.3	9.0	120
Orthoptera	0.0	0.0	0	0.0	0.0	0	0.8	30.0	24	0.4	5.0	2
Bombidae	0.0	0.0	0	0.0	0.0	0	1.7	1.0	2	0.0	1.0	1
Coleoptera	0.5	1.0	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Unidentified	1.4	7.0	10	0.7	5.5	4	8.6	1.0	9	1.7	1.0	2
Mammals												
Ursus americanus	1.3	27.3	36	0.7	1.0	1	2.1	4.0	8	1.2	1.0	1
Procyon lotor	0.0	0.0	0	0.3	35.0	11	4.4	5.0	22	0.4	71.0	28
Lepus americanus	3.2	4.0	13	4.0	6.0	24	1.7	1.0	2	0.8	1.0	1
Castor canadensis	1.4	12.0	17	0.0	0.0	0	0.0	0.0	0	0.4	1.0	<1
Ondatra zibethicus	0.4	30.0	12	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Marmota monax	0.0	0.0	0	0.0	0.0	0	0.9	8.0	7	0.0	0.0	0
Odocoileus virginianus	1.4	1.0	1	0.3	1.0	<1	2.0	1.0	2	0.0	0.0	0
Unidentified	5.5	19.0	105	4.3	8.5	37	2.1	5.0	11	2.5	8.2	21
Total plants	98.6	67.7	6675	98.9	53.1	5252	100.0	60.6	6060	99.2	75.1	7450
Total insects	18.9	5.2	98	60.1	10.6	637	70.7	16.0	1131	32.9	8.0	263
Total mammals	15.2	22.5	342	9.4	10.7	101	9.1	20.1	183	4.2	13.9	58
Birds	0.0	0.0	0	1.0	4.0	4	2.6	3.0	8	0.0	0.0	0
Fish	1.4	1.3	2	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Debris and fine material	100.0	21.3	2130	100.0	22.0	2200	100.0	20.9	2090	100.0	16.7	1670

[a] F = % frequency, C = % volume composition, FI = forage importance value (FI = F X C).
[b] Domestic oats was present all 4 years, but included with grasses in 1976 and 1977.
[c] In 1976 and 1977, 2 species of *Prunus* were identified; in 1978 and 1979, these were combined as *Prunus* spp.
[d] In 1978 and 1979, 2 species of *Pyrus* were identified; in 1976 and 1977, these were combined as *Pyrus* spp.

Table 3. Percent of stands in each forest community in northern Wisconsin (Curtis 1959 and Plant Ecology Laboratory, University of Wisconsin-Madison) in which black bear foods were observed in summer 1978 and 1979.

Food	*Dry Mesic*	*Mesic*	*Wet Mesic*	*Wet*	*Boreal*	*Aspen*	*Alder*	*Sedge Meadow*	*Bog*	*Bracken Grassland*	*Dry Weed*	*Northern Pasture*	*Mesic Weed*
Gramineae and Cyperaceae	91.4	95.1	97.1	100.0	89.7	95.0	91.7	100.0	86.7	100.0	71.4	100.0	100.0
Cornus stolonifera	—	—	41.2	21.6	17.9	35.0	50.0	18.5	—	—	—	—	—
Osmorhiza claytonii	44.4	72.5	32.4	—	39.3	15.0	—	—	—	—	—	—	—
Rubus spp. (raspberry)	47.2	20.0	58.8	27.5	64.3	50.0	8.3	—	—	—	—	—	—
Prunus spp.	54.3	17.5	14.3	6.0	46.4	75.0	8.3	—	6.7	25.6	—	—	—
Arailia nudicaulis	94.4	90.0	94.1	41.2	96.4	80.0	—	—	13.3	—	—	—	—
Amelanchier spp.	50.0	7.5	8.8	—	50.0	60.0	8.3	—	—	18.5	—	—	—
Populus tremuloides	71.4	10.0	31.4	16.0	64.3	100.0	—	—	20.0	40.7	—	—	—
Vaccinium spp. (blueberry)	63.9	12.5	38.2	94.1	50.0	75.0	—	—	66.7	74.1	—	—	—
Trifolium spp.	—	—	—	—	28.6	10.0	—	—	—	44.4	95.2	85.7	100.0
Calla palustris	—	—	8.8	21.6	10.7	5.0	—	7.4	53.3	—	—	—	—
Rubus allegheniensis	58.3	17.5	17.6	—	25.0	70.0	—	—	—	—	—	—	—
Tsuga canadensis	40.0	80.0	48.6	2.0	25.0	5.0	—	—	—	—	—	—	—
Fragaria spp.	66.7	30.0	44.1	—	64.3	95.0	—	11.1	—	85.2	52.4	42.9	30.0
Rhamus alnifolia	—	—	17.6	23.5	7.1	—	—	—	—	—	—	—	—
Lycopodium spp.	82.9	80.0	57.1	58.0	96.4	80.0	—	—	6.7	7.4	—	—	—
Nemopanthus mucronatus	2.8	2.5	26.5	56.9	7.1	15.0	8.3	—	33.3	—	—	—	—
Sambucus pubens	25.0	55.0	8.8	—	32.1	20.0	—	—	—	—	—	—	—
Ribes spp.	38.9	40.0	76.5	35.3	75.0	55.0	50.0	22.1	—	—	—	—	—
Vaccinium spp. (cranberry)	—	2.5	20.0	74.4	—	—	—	—	100.0	3.7	—	—	—
Corylus spp.	83.3	57.5	44.1	—	71.4	90.0	8.3	—	—	40.7	—	14.3	—
Thuja occidentalis	20.0	25.0	91.4	42.0	64.3	15.0	8.3	—	—	—	—	—	—
Abies balsamea	51.4	60.0	80.0	38.0	100.0	95.0	—	—	6.7	7.4	—	14.3	—
Cornus alternifolia	34.3	30.0	20.0	—	10.7	30.0	—	—	—	—	—	—	—
Lactuca spp.	8.6	7.5	28.6	8.0	14.3	40.0	—	—	—	37.0	28.6	—	20.0
Viburnum spp.	72.2	25.0	32.4	—	28.6	65.0	16.7	3.7	—	—	—	—	—
Cornus canadensis	54.3	40.0	71.4	76.0	96.4	90.0	—	3.7	53.3	11.1	—	—	—
Picea glauca	17.1	7.5	20.0	—	89.3	35.0	—	—	—	—	—	—	—
Average[a]	49.2	32.9	39.7	37.8	49.0	52.2	18.5	11.1	36.0	33.0	58.7	39.3	50.0
Number food items[a]	22	24	26	17	26	25	9	6	10	12	3	4	3

[a] Excludes Gramineae and Cyperaceae.

Table 4. Forage importance values[a] indicate the relative importance of each forest community in northern Wisconsin for black bear foods comprising ≥ 2% frequency of occurrence in scats collected during summer 1978 and 1979.

Food Item	Forage Importance Value	Community Importance Values: Dry Mesic	Mesic	Wet Mesic	Wet	Boreal	Aspen	Alder	Sedge Meadow	Bog	Bracken Grassland	Dry Weed	Northern Pasture	Mesic Weed
Gramineae and Cyperaceae	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4	1158.4
Cornus stolonifera	311.4	—	—	311.4	311.4	311.4	311.4	311.4	311.4	—	—	—	—	—
Osmorhiza claytonii	228.6	228.6	228.6	228.6	—	228.6	228.6	—	—	—	—	—	—	—
Rubus spp. (raspberry)	220.9	220.9	220.9	220.9	220.9	220.9	220.9	220.9	—	—	—	—	—	—
Prunus spp.	170.6	170.6	170.6	170.6	170.6	170.6	170.6	170.6	—	170.6	170.6	—	—	—
Arailia nudicaulis	138.6	138.6	138.6	138.6	138.6	138.6	138.6	—	—	138.6	—	—	—	—
Amelanchier spp.	129.5	129.5	129.5	129.5	129.5	129.5	129.5	129.5	—	129.5	—	—	—	—
Populus tremuloides	88.5	88.5	88.5	88.5	88.5	88.5	88.5	—	—	88.5	88.5	—	—	—
Vaccinium spp. (blueberry)	66.8	66.8	66.8	66.8	66.8	66.8	66.8	—	—	66.8	66.8	—	—	—
Trifolium spp.	60.3	—	—	—	—	60.3	60.3	—	—	—	60.3	60.3	60.3	60.3
Calla palustris	52.2	—	—	52.2	52.2	52.2	52.2	—	52.2	52.2	—	—	—	—
Rubus allegheniensis	47.9	47.9	47.9	47.9	—	47.9	47.9	—	—	—	—	—	—	—
Lycopodium spp.	9.5	9.5	9.5	9.5	9.5	9.5	9.5	—	—	9.5	9.5	—	—	—
Ribes spp.	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	—	—	—	—	—
	Sum	2263.8	2263.8	2627.4	2350.9	2687.7	2687.7	1995.3	1526.5	1814.1	1554.1	1218.7	1218.7	1218.7

[a] Forage importance value = % frequency multiplied by % volume composition of food items in scats.

Table 5. Communities in northern Wisconsin where a positive relationship ($P < 0.05$) existed between availability and use of plant foods comprising ≥ 2% frequency of occurrence in black bear scats, summer 1978 and 1979.

Graminae	*Cornus stolonifera*	*Osmorhiza claytonii*	*Rubus spp. (raspberry)*	*Prunus* spp.	*Aralia nudicaulis*	*Amelanchier* spp.	*Populus tremuloides*	*Vaccinum* spp.	*Trifolium* spp.	*Calla palustris*	*Rubus allegheniensis*	*Lycopodium* spp.	*Ribes* spp.
Dry mesic	Wet mesic	Dry mesic	Dry mesic	Dry mesic	Dry mesic	Dry mesic	Dry mesic	Dry mesic	Boreal	Bog	Dry mesic	Dry mesic	Dry mesic
Mesic	Wet	Mesic	Wet mesic	Boreal	Mesic	Boreal	Wet mesic	Wet mesic	Bracken grassland		Mesic	Mesic	Mesic
Wet mesic	Aspen	Wet mesic	Boreal	Aspen	Wet mesic	Aspen	Wet	Wet	Dry weed		Wet mesic	Wet mesic	Wet mesic
Wet	Alder	Boreal	Aspen	Bracken grassland	Boreal		Boreal	Boreal	Pasture		Boreal	Wet	Wet
Aspen					Aspen		Aspen	Aspen	Mesic weed		Aspen	Boreal	Boreal
Sedge							Bog	Bog				Aspen	Aspen
Bracken grassland							Bracken grassland	Bracken grassland				Bog	Alder
												Bracken grassland	Sedge

Appendix A. Forest community terminology used in this study for northern Wisconsin.

Curtis (1959) Terminology	*Dominant Species*	*WDNR[a] Terminology*
Dry mesic forest	*Pinus strobus* *Acer rubrum* *Quercus borealis*	White pine/oak
Mesic forest	*Acer saccharum* *Fagus grandifolia* *Tsuga canadensis* *Betula lutea*	Northern hardwoods
Wet mesic forest	*Thuja occidentalis* *Abies balsamea* *Fraxinus nigra*	Swamp conifer
Wet forest	*Picea mariana* *Larix laricina*	Black spruce
Boreal forest	*Picea glauca* *Abies balsamea*	Fir – spruce
Aspen forest	*Populus tremuloides* *Populus grandidentata*	Aspen
Alder	*Alnus rugosa*	Alder
Sedge meadow	*Carex* spp. *Calamagrostis canadensis* *Aster simplex*	Marsh/muskeg
Bog	*Andromeda glaucophylla* *Chamaedaphne calyculata* *Kalmia polifolia*	Muskeg – bog
Bracken grassland	*Pteridium aquilinum* *Bromus kalmii* *Danthonia spicata*	Herbaceous vegetation
Dry weed	*Conyza canadensis* *Oenothera biennis* *Agropyron repens*	Noncommercial herbaceous vegatation
Northern pasture	*Poa pratensis* *Taraxacum officinale* *Trifolium repens*	Heavily grazed
Mesic weed	*Phleum pratense* *Trifolium pratense* *Plantago major*	Grass

[a]Wisconsin Department of Natural Resources.

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Effects of Trapping on Colony Density, Structure, and Reproduction of a Beaver Population Unexploited for 19 Years

Abstract *A trapline system for beaver* (Castor canadensis) *occurred on Sandhill Wildlife Area during 1981, 1982, and 1983 to harvest populations unexploited for at least 19 years. We censused 48 beaver colonies (1.30/km²) in 1981, 38 (1.03/km²) in 1982, and 18 (0.49/km²) in 1983. Ground counts indicated that 22% of the colonies were missed in aerial counts. A winter harvest of 3.9 beaver/colony in 1981 resulted in a 21% decline in active colonies in 1982; subsequent harvest of 3.2 beaver/colony in 1982 caused a 53% decline in 1983. In 1981 and 1982, 89% of the beaver harvest was achieved during the first 16 days of the season and involved 64% of the trapping effort. Mean age decreased after harvest began, from 2.9 years in 1981 to 2.2 years in 1982. Average colony size was 4.2 in 1981 and 3.1 in 1982. Single and pair colonies occurred as 9% of all colonies trapped in 1981 and 22% in 1982. Family colonies averaged 5.6 beaver in 1981 and 5.2 in 1982. Lack of exploitation might have delayed sexual maturation and dispersal and increased the number of non-breeding adults. In 1981, 35% of the females (N = 51) had placental scars, fewer than the 80% (N = 25) found in 1982. Breeding females averaged 3.1 placental scars in 1981 (N = 56) and 3.6 in 1982 (N = 72). Yearlings reproduced after 1 year of harvest when about 79% of the available colony sites were occupied. The estimated 34% mortality for the unharvested population seemed high, perhaps due to dispersal and tularemia.*

Some effects of trapping have been reported for beaver *(Castor canadensis)* colonies experiencing short (4- or 5-year) season closures (Parsons 1975, Parsons and Brown 1978, Boyce 1981*a*, Payne 1982). No combined effects of trapping on colony density, structure, and reproduction have been studied on beaver populations with long-term season closures.

Nordstrom (1972) and Boyce (1981*a*) compared the population dynamics and density between trapped and untrapped beaver populations. Parsons (1975) and Parsons and Brown (1978) investigated effects of a 4-year closure on beaver trapping in New York, as did Payne (1982) after a 5-year closure in Newfoundland. This study was undertaken to determine the influence of trapping on colony density, structure, and reproduction of a beaver population unexploited for at least 19 years.

Study Area

Sandhill Wildlife Area, in central Wisconsin, has a 2.5-m high deer-proof fence enclosing 37 km^2. The area is managed by the Wisconsin Department of Natural Resources as an experimental and demonstration area with emphasis on wildlife habitat and managed hunting. No furbearer trapping occurred on the area since the state bought the land in 1962; historical furbearer harvest records were unavailable. Habitat composition and forest management on Sandhill were described by Kubisiak et al. (1980). The property has 419 ha of surface water, including 16 impoundments, 39 km of drainage ditch and a 0.8-km segment of stream, which enters and leaves Sandhill. Five drainage ditches, remnants of farming attempts of the early 1900s (Grange 1949), drain out of Sandhill. Drainage ditches and impoundments are major sources of permanent water. Not all are suitable beaver habitat because annual freezeouts occur commonly in many shallow impoundments, which are 0.6-0.9 m deep; drainage ditches average 1.2 m deep. Low marsh fertility was reported by Baldassarre and Nauman (1981), who described vegetation cover types of emergent and submergent species in 2 major impoundments on Sandhill.

Methods

A trapline system for beaver (Payne 1980) occurred on Sandhill during December 1981, 1982, and 1983. Each year, 8 trappers were assigned exclusive traplines and required to report numbers of trapnights and beaver caught in each colony daily. Carcasses were tagged through the tail with self-locking, numbered tags, and returned skinned the next day.

Tag numbers were attached to or placed with the jawbones and reproductive tracts. Reproductive tracts were preserved in 10% formalin and examined (Hodgdon 1949, Leege and Williams 1967). Ages of beaver were determined by basal closure and cementum annuli of teeth (van Nostrand and Stephenson 1964, Klevezal' and Kleinenberg 1967, Larson and van Nostrand 1968).

In fall 1981 before the first trapping season, we conducted an aerial census with a Cessna 337 Skymaster to determine the number of active beaver colonies on Sandhill and an adjacent harvested area of 31 km^2 (Hay 1958, Payne 1981). We conducted an aerial census again in fall 1982 after the first trapping season. In fall 1983, after the second trapping season, the census consisted of complete ground coverage alone, without aerial census. Ground checks also were conducted on Sandhill in 1981 and 1982 to assure complete coverage and to verify colony sites on Sandhill, but ground checks were not conducted on the adjacent area. We used the correction factor between aerial and ground censuses on Sandhill to estimate overall colony density on the adjacent harvested area. Beaver population density was expressed in colonies/km^2 due to the relatively flat terrain and numerous wetlands and impoundments (Hill 1982).

Selection of beaver colonies to be completely trapped each year was based on nuisance activities associated with the colony site. Wisconsin prohibits beaver trapping within 4.6 m of the lodge and/or dam. This restriction was lifted on these selected colonies to facilitate removal of all beaver from the colony to determine colony size, age, and sex structure. Complete removal was determined by placing a piece of quaking aspen *(Populus tremuloides)* through the ice near the lodge entrance; evidence of gnawing on the branch indicated the presence of additional beaver (Payne 1982). Trappers provided additional information regarding presence of beaver activity.

We used chi-square analyses to test for difference between data sets. P values ≤ 0.05 were considered significant.

Results

Colony Density and Harvest

We observed 48 colonies (1.30/km^2) in 1981, 38 (1.03/km^2) in 1982, and 18 (0.49/km^2) in 1983 on Sandhill. In 1981 and 1982 our aerial census missed 22% of the colonies on Sandhill counted on the ground. Thus, the 13 colonies aerially censused on the adjacent harvested area were adjusted 22% higher, i.e., to 15 colonies (0.48/km^2). After the second trapping season on Sandhill, the colony density was similar to that on the adjacent harvested area.

The beaver harvest was 182 in 1981, 116 in 1982, and 4 in 1983. In 1981 and 1982, 89% of the beaver harvest was achieved during the first 16 days of the season and involved 64% of the trapping effort, although the season was 31 days long and each of the 8 trappers had an exclusive trapline. All beaver were removed from 11 of 23 colonies scheduled to be completely trapped in 1981, and from 12 of 25 colonies in 1982. During 1983, only 2 colony sites were recolonized after all beaver were removed from them in 1981 and 1982. In 1981, 137 beaver were removed from 35 incompletely trapped colonies ($\bar{x}$ = 3.9/colony), and 81 were removed from 25 incompletely trapped colonies in 1982 ($\bar{x}$= 3.2/colony).

Colony Size and Structure

In 1981 and 1982 the sex ratio of 75 beaver (97 males:100 females) from 23 completely trapped colonies, and 223 beaver (85 males:100 females) from incompletely trapped colonies, did not differ. Mean age decreased after harvest began, from 2.9 years in 1981 to 2.2 years in 1982 (Table 1).

Average colony size was 4.2 from 11 colonies trapped out in 1981 and 2.9 from 12 colonies trapped out in 1982, averaging 3.5 both years (Table 2). But in 1982, more beaver/colony were trapped from the 25 incompletely trapped colonies (3.2) than from the 12 completely trapped colonies (2.9). (One colony was not trapped in 1982.) Thus, the average colony size on Sandhill in 1982 was at least 3.1 ([81beaver trapped from incompletely trapped colonies + 35 beaver trapped from completely trapped colonies] ÷ 37 total colonies trapped). More single (1 beaver) and pair (2 beaver) colonies existed in 1982 than in 1981 (Table 3). Single or pair colonies occurred as 9% of all colonies trapped in 1981 (N = 46) and 22% in 1982 (N = 37). The average size of completely trapped family colonies was 5.6 beaver from 7 colonies in 1981 and 5.3 from 4 colonies in 1982, averaging 5.5 both years.

Of 35 family colonies incompletely trapped, at least 26% had 2.5-year-olds in 1981 (N = 35) and 0% in 1982 (N = 25). In 1981, 2 family colonies completely trapped had $\geq$ 4 beaver $\geq$ 2.5 years old. Each of these colonies had 2 or 3 beaver 2.5 years old. Of the 11 family colonies completely trapped, 3 (27%) had 3 beaver $\geq$ 2.5 years

Table 1. Age structure of beaver trapped after 19 years of no harvest (1981) and 1 year after harvest (1982) on Sandhill Wildlife Area.

Age	*1981*		*1982*	
(years)	*N*	*%*	*N*	*%*
0.5	62	43	67	58
1.5	42	23	11	9
2.5	23	13	8	7
3.5	12	7	6	5
≥ 4.5	43	24	24	21
Total	**182**	**100**	**116**	**100**
≥ 1.5	120	66	49	42
≥ 2.5[a]	78	43	38	33
≥ 3.5	55	30	30	26

[a] Beaver normally disperse at age 2.5 years.

Table 2. Average colony size from beaver colonies completely trapped on Sandhill Wildlife Area, 1981–82.

Colony Type	*1981*[a]	*1982*	*Both*
Family (≥ 3 beaver)			
Beaver	39	21	60
Colonies	7	4	11
Beaver/colony	5.6	5.3	5.5
Single and pair			
Beaver	7	14	21
Colonies	4	8	12
Beaver/colony	1.8	1.8	1.8
Combined			
Beaver	46	35	81
Colonies	11	12	23
Beaver/colony	4.2	2.9	3.5

[a] No beaver were harvested during the previous 19 years; in 1981, in addition to the 46 beaver trapped from these 11 colonies, another 136 beaver were trapped from 37 other colonies.

old. Yearlings occurred in 8 of the 9 pair colonies completely trapped both years.

In 1981, one colony had 14 beaver removed. Six age classes were present: three kits, four yearlings, three 2.5-year-olds, two 3.5-year-olds, one 8.5-year-old, and one 10.5-year old. Reproductive tracts from two females indicated previous parturition.

Reproduction

All 11 completely trapped family colonies contained kits. In 1981, all 7 family colonies completely trapped had 15 kits (2.14 kits/colony); in 1982, all 4 family colonies had 12 kits (3.00 kits/colony). Of the beaver trapped from all colonies, kits comprised 34% in 1981 and 58% in 1982.

In 1981, 35% of the females (N = 51) had placental scars, fewer than the 80% (N = 25) found in 1982. Number of breeding female yearlings was 0 in 1981 and 2 in 1982. Excluding yearlings, 58% (N = 31) had placental scars in 1981, fewer ($P < 0.05$) than the 86% (N = 25) in 1982. Breeding females averaged 3.1 placental scars in 1981 (N = 56) and 3.6 in 1982 (N = 72). A difference existed between the 2 means when the breeding yearlings were excluded.

Logarithmic regression of female age (kits and other barren females omitted) and mean number of placental scars/female resulted in a correlation coefficient of 0.563 (N = 51) in 1981 and 0.579 (N = 25) in 1982. No females younger than 3 years bred in 1981; yearlings and 2-year-olds bred in 1982.

Mortality

In 1981, the average colony size (4.2) times the number of colonies (48) indicated a population of 202 beaver, of which 182 (90%) were harvested. In 1982, the average colony size (at least 3.1) times the number of colonies (38) indicated a population of at least 118 beaver, but 116 were harvested, probably indicating some inaccuracy in population estimates and almost 100% removal, although 18 colonies were censused in 1983.

If the population were stationary in 1981 because no previous harvesting or other unusually high mortality occurred, then life table analysis (Payne 1984*a*) of the sample

Table 3. Number of single, pair, and family beaver colonies trapped on Sandhill Wildlife Area, 1981–82.

Year	Single N	Single %	Pair N	Pair %	Family N	Family %	Number Colonies Trapped	Number Colonies Present
1981[a]	1	2.2	3	6.4	42	91.3	46	48
1982	2	5.4	6	16.2	29	78.4	37	38
1981–82	3	3.6	9	10.7	71	85.5	83	86

[a] No beaver were harvested the previous 19 years; in 1981, 46 beaver were trapped from 11 completely trapped colonies, and another 136 beaver were trapped from the other 37 colonies.

from 1981 indicated an annual mortality of 34%. Because the population in 1981 had been unharvested previously, the 34% annual mortality represents the natural mortality of previous years, when no harvest mortality occurred, assuming balanced rates of ingress and egress. In 1981, the 2.1 kits/colony and the 3.1 placental scars/breeding female indicated a mortality rate of 32% for kits from parturition until the trapping season.

Discussion

Colony Density and Harvest

Beaver colony density throughout North America varies widely, from 0.15 to 4.6/km^2 (Novak 1987), and depends on habitat quality, trapping intensity (Larson and Gunson 1983), and mutually exclusive territories (Semyonoff 1951, Nordstrom 1972, Bergerud and Miller 1977, Busher et al. 1983, Buech 1985, Nolet and Rosell 1994). Availability of suitable sites for lodge and cache construction, adequate forage, and geomorphology influence distribution of colonies (Boyce 1981*b*, Johnston and Naiman 1990, Fryxell 1992). For example, beaver populations increased in Ontario when active forest management replaced conifers with deciduous trees (Ingle-Sidorowicz 1982).

After 19 years of closure, the beaver colony density of 1.30 colonies/km^2 was high on Sandhill compared to an adjacent trapped area (0.42/km^2). Unexploited populations in Alberta indicated 1.06 colonies/km^2 in 1976, 1.07/km^2 in Manitoba during 1973–80 (Larson and Gunson 1983), and 0.34/km^2 in Newfoundland (Payne 1984*b*) where habitat quality for beaver is marginal (Payne 1984*a*, 1984*b*). Comparison of trapped and untrapped populations indicated higher densities without trapping in New Brunswick (Nordstrom 1972) and New York (Parsons and Brown 1978).

Parsons and Brown (1981) reported a harvest of 2.0 beaver/colony, resulting in a 39% decline of active colonies with a 37-day February–March trapping season in New York. Similar seasons appeared to stabilize the population at the reduced level. During a 14- to 16-day February season resulting in a harvest of 1.8 beaver/colony in New York, number of colonies declined 27% initially; similar seasons increased the original beaver population level (Parsons and Brown 1981). Trapping season length accounted for annual variation in Missouri beaver harvests (Erickson 1981). Reduced season length would reduce the harvest, but the reduction must be substantial, perhaps greater than 50%, to compensate for harvest effort concentrated into the shorter season (Erickson 1981). On Sandhill, for example, the harvest would have had to have been less than 16 days long, because 89% of the harvest occurred in the first 16 days.

After 19 years of closure, winter harvest intensity of 3.9 beaver/colony in 1981 reduced the colony density by 21% in 1982; winter harvest intensity of 3.1 beaver/colony in 1982 reduced the colony density by 53% in 1983. Colony density during 1983 was reduced to levels found in the trapped population censused outside Sandhill in 1981, which had similar habitat.

Ground counts of colonies exceeded aerial counts with a Cessna by 22% on Sandhill, compared to a Newfoundland survey (Payne 1981) in which ground counts exceeded aerial counts with Super Cubs by 39% and with helicopters by 19%. Cache surveys are reliable in indicating population size or trend of beaver when the average colony size is known (Swenson et al. 1983).

Colony Size and Structure

Exploitation of beaver on Sandhill reduced the mean age and number of adults. The mean age of 2.9 years for the 11 completely trapped colonies in 1981 is similar to the 2.98 years that Boyce (1974) found for 11 completely trapped colonies in Alaska, but differs from the 3.81 years that Payne (1982) found for 11 completely trapped colonies previously unharvested in Newfoundland. Nordstrom (1972) found that untrapped populations contained more adults than trapped populations did and that higher beaver density in untrapped populations results in reduced productivity and fewer beaver in the younger age classes.

Social organization of beaver colonies seems more variable than often assumed (Busher et al. 1983). More single and pair colonies were found on Sandhill the year after trapping than the previous year, as Payne (1982) found, but the proportions varied from the 14–19% single, 13–24% pair, and 59–68% family colonies in populations reported by Gunson (1970), Payne (1982), and Peterson and Payne (1986). Changes in the proportion will affect census results based on colony counts (Swenson et al. 1983). Young populations will have a smaller average colony size because more pair and single colonies occur, and family colonies are smaller. Also, nuisance colonies often are smaller than normal because they are trapped out repeatedly, leaving no time to expand (Peterson and Payne 1986). This situation might have occurred on Sandhill, resulting in a smaller than average colony size, after some nuisance colonies were trapped out.

More yearlings occurred in pair colonies on Sandhill the first year, a possible result of high colony density (Payne 1982). The average colony size decreased after exploitation due to harvest mortality and dispersal of beaver $\geq$ 2.5 years old. Family colonies normally do not contain 2.5-year-olds due to normal dispersal of juveniles when they are 2 years old (Leege 1968), although 2.5-year-olds usually are found in colonies further north (pers. comm. M. Boyce, University of Wisconsin-Stevens Point). Failure to disperse has been attributed to lack of colonization sites and high colony density (Novakowski 1965, Nordstrom 1972, Bergerud and Miller 1977, Payne 1982). Individuals delaying dispersal could be larger and behaviorally more prepared for future dispersal (Novakowski 1965). Delayed dispersers could therefore have a selective advantage over younger dispersers at high population densities when suitable colony sites are limited (Boyce 1981*a*, Molini et al. 1981).

Reproduction

An increase in the pregnancy rate, mean litter size, and percentage of kits trapped suggests compensatory reproduction in beaver on Sandhill after 1 year of exploitation. The adult (≥ 2.5 years) pregnancy rate (86%) in 1982 after 1 year of harvest on Sandhill was similar to the 87% in north-central Wisconsin reported by Peterson and Payne (1986) for a regularly harvested population. The pregnancy rate (58%) in 1981 was similar to that of a lightly harvested beaver population in South Dakota (62%) in 1986 (Dieter 1992), but low compared to unexploited populations in Newfoundland (71%) (Payne 1984*b*), Massachusetts (87%) (Lyons 1979), and New York (86%) (Parsons and Brown 1978). In Newfoundland, pregnancy rates of exploited (70%) and unexploited (71%) beaver populations were similar (Payne 1984*b*). Reduced pregnancy rates after fall harvest have been reported in Idaho (Leege and Williams 1967), Maine (Hodgdon and Hunt 1955), and Minnesota (Longley and Moyle 1963) due to potential disruption of the dominant breeding pair. The increased pregnancy rate on Sandhill during 1982 suggests replacement of a dominant breeder by a delayed disperser (Brooks et al. 1980, Payne 1984*b*), because the percentage of colonies with such breeders was high and probably density dependent (Molini et al. 1981). Correlation coefficients suggest a weak relationship between progressive age of females and increased productivity, as Payne (1984*b*) found.

Delayed sexual maturation might have reduced reproduction of beaver before exploitation. After exploitation, yearlings bred and the number of non-breeding adults decreased. Lack of exploitation of beaver can delay age at first reproduction (Lyons 1979, Boyce 1981*a*) and increase the number of non-breeding adults (Nordstrom 1972). No yearlings bred in a lightly harvested population in South Dakota (Dieter 1992). Parsons and Brown (1979) found little or no yearling reproduction when more than 40% of the potential colony sites were occupied. Unexploited populations have available colony sites saturated with territorial adults; fewer dispersers can colonize them (Boyce 1981*a*). Payne (1975) found about 6% of the yearlings bred on a 179-km^2 island in Newfoundland, which contained 60 colonies after 5 years of no harvest, of which 90% occurred on only 27% of the 190 lakes and ponds (Payne 1989). But Payne (1984*b*) found that 24% of the yearlings bred from exploited populations. Probably most or all available colony sites were occupied on Sandhill in 1981 after 19 years of unexploited growth. In 1982, yearling reproduction was found after 1 year of harvest when about 79% of the available colony sites was occupied. Although uncommon in beaver, if many yearlings disperse and establish colonies, yearling reproduction can be important to beaver population growth (Payne 1982, 1984*b*). Beaver productivity is characterized by low average litter size and pregnancy rates for young and old beaver, with peak production during middle years (Payne 1984*b*). Despite increased reproduction in older and potentially more productive beaver, the population declined after 2 years of intensive harvest on Sandhill when harvest mortality apparently exceeded the capability for compensatory reproduction and immigration.

Mortality

Estimated population levels and the heavy harvest intensity indicated substantial immigration of beaver into Sandhill in 1982 and 1983, as well as the documented increase in reproduction. Although colony density appeared substantially lower in the adjacent trapped area, dispersal probably occurred into the heavily trapped Sandhill area. Although only 11 colonies were definitely documented to have been trapped out, with

46 beaver removed, 136 beaver, or 3.8/ colony, were trapped from the other 36 colonies trapped. (Two additional colonies were untrapped.) Because colony size of the 11 trapped out colonies was 4.2, the 3.8 beaver trapped/colony from the other 36 colonies indicates most of the 36 colonies also were trapped out in 1981. Yet in 1982, 38 colonies occurred.

The estimated annual mortality (34%) before 1981 for the unharvested beaver population on Sandhill seems higher than the 28% from unharvested and 27% from harvested populations in Newfoundland (Payne 1984*a*), and the 31% calculated from those exploited in Saskatchewan (Gunson 1970). The higher rate on Sandhill might be due to higher egress than ingress of dispersing juveniles from an unharvested population on Sandhill to adjacent harvested populations. During winter 1981, tularemia *(Francisella tularensis)* was identified in beaver on Sandhill and might have increased mortality above normal. Four beaver colonies were eradicated by tularemia in 1981. Tularemia epizootics have been linked to overpopulation in beaver (Banfield 1954). Tularemia outbreaks were not documented on Sandhill before 1981. If the beaver population were decreasing from tularemia before 1981, then the population would not have been stationary, and the mortality estimate of 34% would have been low (Caughley 1977).

Many of the shallower impoundments and associated wetlands freeze solid in winter on Sandhill, resulting in inaccessible browse piles and possible starvation of the colony, which might be limiting. Other studies in the Northwest Territories (Aleksiuk 1968) and Alaska (Boyce 1974) found that winter starvation might be limiting or at least it might limit sites that can be occupied longer than 1 season.

Management Implications

Beaver populations often attain nuisance status with human encroachment of beaver habitat, which usually results in efforts to control beaver populations. However, the number of beaver trappers in Wisconsin has declined because pelt prices have declined. Reduced competition also has resulted in more nuisance beaver complaints (Payne and Peterson 1986), as fewer beaver are trapped, and some trappers "farm" their areas to leave breeding stock for future years. With interested, dedicated trappers, a trapline system of harvest can be effective in achieving population control and a high annual harvest of beaver (Payne 1980).

Beaver trapping in Wisconsin in late fall-early winter, when pelts are less prime but still valuable, could increase trapping effort and beaver harvest due to milder temperatures, open water or less ice, and more beaver activity around the lodge compared to later or long beaver seasons. A harvest of more than 3.0 beaver/colony might be needed in saturated populations to exceed capability for compensatory mortality and reproduction the first year; perhaps lower harvests thereafter would then produce reduced beaver populations (Payne 1989). Eliminating trap restrictions that prohibit trapping near the lodge would facilitate complete removal of nuisance colonies. Removal of an adult after freeze-up but before the breeding season will reduce pregnancy rates. Replacement of a dominant breeder by a subadult probably will result in smaller litters and lower survival of offspring.

Maintaining beaver populations at reduced levels would lower the minimum breeding age and would prevent females from reaching ages of optimal productivity (Payne 1984*b*). Regular harvest without complete removal would maintain territories and prevent dispersers from recolonizing vacant colony sites. Colonization can be inhibited by constructing artificial scent mounds around potential beaver sites (Welsh and Müller-Schwarze 1989). Maintaining conifers or advanced seral stages of vegetation along water would deter colony site selection, spacing, and reproduction (Boyce 1981*b*). Other methods can be used to reduce beaver populations (Hammerson 1994).

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