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Contents

From the Editor

After completing work on Volume 74, 1986, Philip and Kathryn Whitford resigned as editors of *Transactions*. Their dedicated work for the journal, sometimes under difficult circumstances and without adequate support staff, is greatly appreciated. As the new editor I wish to acknowledge their contribution, and on behalf of all associated with the journal, to express our sincere thanks to the Whitfords for their excellent work. My hope is to maintain the standards of judgment, breadth of view, and quality of product so long evident under the Whitfords' editorship.

Readers will note only modest changes in the 1987 volume of the journal. There are a few technical changes in this issue, but the addition of assistant editors and a production editor has already meant an increase in the services we have been able to provide to authors. And recent changes at the Academy office plus the support that naturally comes from being associated with a university campus, have increased the resources available to the journal. No dramatic changes are anticipated though I do plan to include more material from arts and letters. The next volume will have a poetry section, and consideration is being given to a photographic essay, a series of profiles of Wisconsinites, an interview, and original ink drawings or woodcuts. It is my hope that *Transactions* will reflect the diverse interests and activities of the members of the Wisconsin Academy as well as continue to serve as a place to present original work by Wisconsin writers or about Wisconsin.

Three aspects of this volume of *Transactions* should be noted. The first is the inclusion of the Bruce Taylor poem, which gives some indication of things to come. Bruce has agreed to serve as poetry editor for the 1988 volume. The second is the unusually long and detailed lead article entitled "Wisconsin Death March." In this article Professor Clifton meticulously reconstructs the story of an episode in American and Wisconsin history that injected suspicion and bitterness into the relationship between the Chippewa Indians and various agencies of the government. The article serves as an ideal background against which to place the current arguments over the Chippewa's exercise of rights they reserved by treaty. The 1987 volume concludes with another article in a series that began a number of years ago. Botanists are studying the flora of Wisconsin, and *Transactions* was selected as the journal to publish the occasional reports. When the study is completed, this journal will be the major source of information for anyone studying the flora of Wisconsin. We are pleased to continue our participation in this project with the publication of the report on Euphorbiaceae—The Spurge Family.

All of us at *Transactions* hope that you enjoy this volume and that you will consider submitting ideas or completed works for possible publication.

Carl N. Haywood

Wisconsin Death March: Explaining the Extremes in Old Northwest Indian Removal[1]

James A. Clifton

Throughout the fall of 1850, four officials of Zachary Taylor's administration conspired to lure the Lake Superior Chippewa Indians away from their lands in Northern Wisconsin and Michigan's Upper Peninsula.[2] Two of these officials, Secretary of the Interior Thomas Ewing and Commissioner of Indian Affairs Orlando Brown, provided the initial approval for the plan, but they did not remain in office long enough to witness its disastrous results. The others, Minnesota Territory's governor, Alexander Ramsey, and Sub-Agent John Watrous, were directly involved as prime movers from start to end. By moving the place for the annual annuity payments to a new temporary sub-agency at Sandy Lake on the east bank of the upper Mississippi and by stalling the delivery of annuity goods and money, they planned to trap the Chippewa by winter weather, thus forcing them to remain at this remote, isolated location.

This scheme, kept secret from both local Americans and the Chippewa, was designed to break the tenacious resistance of these Indians, who had rebuffed earlier efforts to persuade them to resettle in northwestern Minnesota. The stratagem failed. It succeeded only in reinforcing the opposition of the Chippewa to relocation even though it had killed large numbers of them: of the some three thousand (mostly adult males) who gathered at Sandy Lake in early October, some four hundred died before the survivors could make their way back to their homes by the following January.[3]

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This incident was demonstrably atypical of the experiences of the two dozen other Indian populations in the Old Northwest who were subject to the Indian Removal policy between 1825 and the early 1850s.[4] On the contrary, judged by the degree of physiological stress and the casualty rate suffered during the relocation process, the Lake Superior Chippewa case represents an extreme. As such, it deserves special attention, since it and others like it generated much contemporaneous commentary while exposing the interests, aims, and intrigues of the diverse denominational, political, economic, and ethnic interests directly involved. Moreover, because it represents one extreme, to be fully understood, this Chippewa case must be compared with other cases of Old Northwest Indians subject to dislocation and resettlement. By examining the Lake Superior Chippewa case both intensively and comparatively, we can better appreciate how Old Northwest Indian communities reacted resourcefully and variously to American policy initiatives. In the Chippewa case the Indians drew effectively on a variety of relationships with and the support of Wisconsin citizens to oppose the interlocking national, regional, and local patronage system which, rather than "settlement pressure," had fueled the drive for their relocation.

Although these Chippewa were certainly victimized by a few American officials and punished by events under no individual's control, ultimately they emerged from this confrontation as victors. During the three years following the abortive effort to dislodge them, they effectively maneuvered, procrastinated, and negotiated to a standstill those functionaries still bent on their dislocation, and in the end achieved their major goal of remaining on reservations within their preferred habitats in Wisconsin and Michigan by explicit treaty-specified right. Moreover, the Chippewa were not alone among the Indians of the Old Northwest in successfully thwarting American efforts to implement the removal policy. Systematic study of the diverse responses of the two dozen groups of Indians in the region subject to the various tactics of Americans to move them west makes this eminently clear and contributes further insights into the distinctive features of the Chippewa case.

Of the more than forty efforts between 1825 and 1855 to bring about the westward resettlement of Old Northwest Indians, there were just four where outright force, or—as in the Chippewa example—furtive deception and trickery, were employed to produce the results desired by federal administrators. In these few cases, the coercive tactics used contributed to extraordinary hardship and fatalities, consequences that can be, in some part, plausibly attributed to the actions of American authorities. The other three involved Black Hawk's band of recalcitrant Sauk, Fox, and Kickapoo in 1831–1832, certain villages of the Indiana Potawatomi in 1838, and the Winnebago intermittently over the course of a decade and more after 1838.[5]

Although each of these four cases had its own distinguishing features, they shared a series of specific common antecedents, one or more of which were lacking in all other attempts to dislodge and to relocate groups of Old Northwest Indians. These features in combination conditioned the resort by Americans to coercion or deception. In sequence, the first of these was a serious, prolonged, public dispute over the legitimacy of a treaty obligation, with the Indians vehemently denying the right of Americans to demand the surrender of particular tracts and their resettlement and with their adversaries hewing to the right to evict. Next, such a dispute had to be moved to a crisis point, with the Indians adamantly rejecting further American efforts at verbal persuasion and the various incentives proffered. Finally, there had to be present politically influential local Americans with strong vested interests in securing the dislocation, transportation, and resettlement in particular places of the Indians involved. These interests were varied and intertwined. They included some combination of local political prestige, career enhancement, visionary dreams of ecclesiastical colonies, control of patronage resources, profound power needs, ideological convictions, the need for immediate income, the aim of thwarting rivals, the lure of capital accumulation, and others more or less distinguishable in the historical record.[6]

Lacking one or more of these three conditions, American authorities did not use force to drive Indians west in a manner that fits the "Trail of Tears" stereotype. Ordinarily, officials relied on personal influence, on oral argument (enumerating what they defined as the positive inducements for moving and the disincentives for remaining), and on the dispositions of the Indians to cooperate in what must be defined as encouraged, but not forced, migrations. Similarly, numerous groups of Old Northwest Indians, sometimes differing with Americans on the stipulations in treaty engagements, sometimes not, did not press the issue, but in-

stead escaped or evaded the removal policy entirely. By avoiding direct confrontation, such dissidents avoided a situation in which Americans were moved to use the exorbitantly expensive, often ineffective, and morally demeaning option of armed escort and manifest compulsion.

Three different cases together represent the antithesis of the Lake Superior Chippewas' extraordinary experience. In September, 1837, the Mdewakonton Dakota (Sioux), for example, sold their remaining claim to lands in western Wisconsin in what has been called a "removal" treaty. However, their relocation was to them a profitable non-event. As their capable agent, Lawrence Taliaferro, remarked in 1836, they were only maintaining the semblance of a presence in their former territory east of the Mississippi "so as to get a good price for it in case of a desire on the part of the U States to purchase."[7] They had earlier abandoned these lands, owing to pressures from intrusive Chippewa and other ecological and social imperatives (well described by Gary C. Anderson).[8] With the help of Agent Taliaferro, who blew fluff into the ears of Washington officials about the desirability of "removing" these Indians to the west, the Dakota leaders then negotiated a treaty that provided them nearly a million dollars for lands they could neither safely occupy nor productively use. As of the fall of 1837, there were no Dakota east of the Mississippi to be "removed." Prompted and advised by Taliaferro, they had seen in the removal policy an opportunity for large profits at no cost to themselves. The Dakota were not alone among Indians of the region who recognized positive incentives in American initiatives that others, such as the Chippewa bands nearby, defined as menacing rather than beneficial.

Among those Indians who found opportunities in the removal policy were two groups that could not be touched by American authority, for they were British subjects residing in Canada. These voluntary participants came from among the Hurons of Anderdon Township and the Christian Indians (i.e., Moravian Delaware) of New Fairfield, Canada West. Both represented schismatic divisions of fully Christianized, literate, self-governing, predominantly English-speaking communities organized as townships in the Province of Canada.[9] In both these cases, the decision to emigrate came after a long irresolvable factional dispute involving efforts of the Crown to purchase large portions of their reserved estates. Those who elected to emigrate were groups who favored both the sale and emigration to the West, moves long blocked by their rivals.

In neither instance was there a hint of American influence during the preliminaries. Instead, responding to solicitations from related peoples with similar concerns in the United States, both the Moravian and the Huron factions approached American authorities for permission to participate in the removal program. For the Moravians, the invitation had come from the "Missouri Party" of the Stockbridge-Munsee in eastern Wisconsin, a faction which also favored resettlement.[10] Theirs was a considerable feat-of-arms, certainly demonstrating great enthusiasm for the journey. For in 1837 some 202 Moravians departed the Thames River valley in open Mackinaw boats, rowing their way across the western Great Lakes, via the Green Bay-Fox-Wisconsin River waterway to the Mississippi, and then traveling by steamer to St. Louis and eastern Kansas. In 1843, fewer Anderdon Hurons traveled west—making an easier trip of it by canal boat and river steamer—with their relatives and Methodist confreres among the Ohio Wyandot. In neither instance did all from these Canadian emigrant parties long remain in the Indian Territory.[11] Many soon leased

or sold their "head rights" to the land they had acquired and promptly returned to Canada.

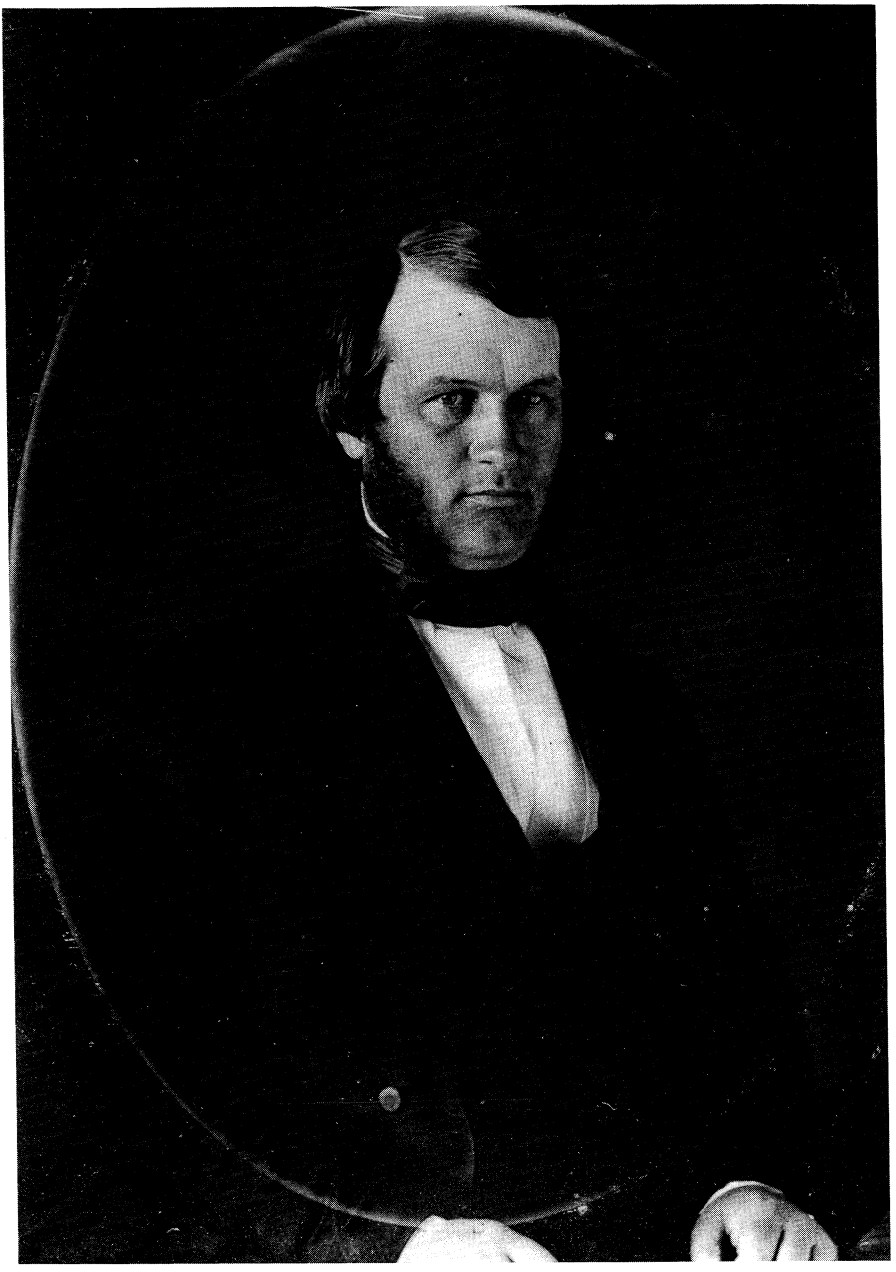
In contrast were the responses of several major groups of Indians that evaded or avoided the plans of Americans by one device or another. Numerous Potawatomi, Ohio Ottawa, and smaller numbers from other tribes slipped across the international border, using Canada as a temporary or permanent refuge, while others moved into northeastern Michigan or northern Wisconsin. Then there were more who—like those master escape artists, the Winnebago—simply refused to stay put after being repeatedly transported west of the Mississippi.[12]

Moving Indians into western lands selected by Americans for their supposedly exclusive and permanent occupation was one matter; keeping them there was an entirely different and often far more difficult one. As the exasperated Governor Alexander Ramsey complained from Minnesota Territory in the fall of 1851, "No argus-eyed vigilance on the part of officers of the Indian department can erect a Chinese wall between this tribe [the equestrian Winnebago] and the inhabitants of Wisconsin."[13] His annoyance stemmed not only from the reluctance of dislocated Indians to stay where they were replanted, but also from the willingness of many Americans near their former homes to tolerate or even ease their return. Obviously, the removal policy at this date was out of tune with the disposition of peregrinating Indians and with the sentiments of numerous citizens of Wisconsin and Michigan as well.

Although his grievance was expressed a year after the scheme for displacing the Lake Superior Chippewa was conceived and set in motion, Ramsey had been one of the four actors most responsible for the design and through 1851 had actively promoted efforts to carry it out. If other Indians like the Winnebago could not—short of building and manning a "Chinese wall"—be separated from their old homes, then what sense was there in Ramsey's conniving to transport west yet another large population of manifestly unwilling, notably ambulatory Indians?

That the Chippewa were to be settled within the governor's jurisdiction, however temporarily, is but part of a necessarily complex answer to this query. There were, to be sure, considerable political and economic rewards to be gained simply from the business of transporting Indians westward, as Ramsey knew, even should they immediately countermarch. Yet this fragment of an explanation still leaves a larger puzzle. How, in 1850, did a Secretary of the Interior, a Commissioner of Indians Affairs, a Territorial Governor, and a lowly Indian Sub-Agent come to concoct a scheme that, in the end, caused the loss of many Chippewa lives and yet left the Chippewa in Wisconsin?

The scheme was designed a dozen years after Andrew Jackson and other leading advocates of removal had declared implementation of the policy a success, "as having been practically settled."[14] The United States of 1850 was no longer the geographically compact republic anticipated in 1803 when Jefferson first conceived of defusing federal-state tensions by displacing unwanted Indians into a vast, newly acquired western territory. Nor was it the developing nation of 1825, when a "permissive" policy of community-by-community resettlement was issued by Executive Proclamation, or that of 1830, when the formal, comprehensive, nationwide provisions of the Indian Removal Act obtained congressional sanction.[15] By 1850, the ideology of Manifest Destiny had been announced and affirmed, the Mexican war won, Continentalism achieved. No national leader could any longer confidently believe that conflicts involving culturally alien, not read-



Alexander Ramsey. Governor and Superintendent of Indian Affairs for Minnesota Territory, Alexander Ramsey was a prime mover in the effort to dislodge the Wisconsin Chippewa bands and to move them and their treaty granted resources into his jurisdiction. Courtesy of the Minnesota Historical Society.

ily assimilable Indians might be avoided by relocating them "permanently" in a huge western Indian Territory on lands that would be forever theirs. By 1850, this was no more a realistic plan than was the abortive parallel policy of reducing sectional tensions over slavery by repatriating Afro-Americans to Liberia.[16]

The political pressure for Indian Removal was effectively removed by events of the latter 1840s, which saw the emergence of a geographically larger, socially more complex United States. The new continental nation was far more diverse ethnically than it had been when the removal and repatriation schemes were conceived. Nevertheless, through the 1830s and 1840s the promise of permanency of tenure on tribal lands in an exclusively Indian Territory legislated in the 1830 Removal Act (essentially a segregated native homeland or apartheid policy) was confirmed in every proper removal treaty. No such stipulation was included in those negotiated with the Lake Superior Chippewa in 1837 and 1842 for the cession of their lands east of the Mississippi. The 1850 effort to dislodge them from Wisconsin and to resettle them near Sandy Lake—east of the Mississippi —involved a temporary location only, because of their specific history of dealings with the United States.

Occupying the farthest northwestern reaches of the Old Northwest, the Lake Superior Chippewa were the last Indians of that Territory to have their independence erased by formal treaty agreement with the United States. Although placed under nominal American sovereignty in the 1783 Treaty of Paris and again in the Treaty of Greenville in 1795, this was a status unknown to these Indians—who remained in a position of unqualified political autonomy. The degree of their continuing independence was marked by two developments. Unlike other foraging bands near them, they had sat out the War of 1812, declining British invitations to join in active military operations. Thus, not considered enemies by American authorities, they did not participate in any of the several subsequent peace treaties pressed on neighboring Indians—including related Chippewa bands—when hostilities ended. These postwar compacts restored the status quo antebellum and required a fresh acknowledgement of American authority in the region, which the Lake Superior Chippewa had yet to deliver. Moreover, throughout the removal era, the Lake Superior Chippewa continued a century-old pattern of warfare against their Dakota neighbors, as good a measure as any of their autarchy and a major concern of Americans attempting to impose peace on this frontier.

Such concerns were expressed between 1825 and 1827, when three treaties were required at last to bring all these small, scattered Chippewa bands under some measure of American authority.[17] These agreements established the meets and bounds of Lake Superior Chippewa lands, declared a "peace" between the Chippewa and their Indian neighbors, defined a new subordinate political status for them, and included provisions for modest educational services and the payment of a minor annual annuity. So far as American authorities were concerned, these Chippewa thereby became dependent client societies.

Yet for a decade these agreements had little consequence for the daily lives of these Indians. No lands were ceded, while the small annuity fund and scanty Indian Office services provided were delivered mainly to those Chippewa living near Sault Ste Marie. For another full decade, contacts between the Lake Superior Chippewa and Americans, other than traders and a few ineffective missionaries, remained occasional and minor. However, these three treaties expressed the legal foundation for the Chippewa's political

and economic future. The "tribal" boundary agreements, for example, were intended to ease, and were later used for, land sale negotiations, whereas at Fond du Lac (Duluth) in 1826, American negotiators had obtained a vaguely defined privilege from the Chippewa: "to search for, and carry away, any metals or minerals from any part of their country."[18] Sixteen years later, when at La Pointe the Chippewa were pressed hard to cede their last remaining lands east of the Mississippi River, this seemingly minor stipulation about exploration for mineral samples was used as a weapon to defeat their resistance.

For nearly a decade following acknowledgement of their dependent status, few new settlers or entrepreneurs appeared among them, especially in the interior away from the watercourses. Then, in 1836, a variety of developments prompted both Chippewa leaders and American authorities to arrange the first of a series of land cession treaties. Among the Chippewa, the initiative came, significantly, from those along the upper Mississippi River, who with other bands were increasingly disturbed by declining income from the fur trade and were jealous of neighboring native peoples receiving annuities from the United States when they had none. Taking advantage of Joseph N. Nicollet's exploration of the Mississippi's headwaters, these Chippewa sent a delegation with this French astronomer-mathematician on his return to Fort Snelling. There Flat Mouth of the Pillager band near Leech Lake, the most prominent leader among the Mississippi bands, declaimed a list of their miseries and wants. Other tribes, including the Chippewa of Michigan, he complained to Agent Lawrence Taliaferro, "are doing better than us. They have treaties we hear, and they have goods and money. . . . We hear of treaties every day with our Nation on the lakes and yet not a plug of tobacco reaches us on the Mississippi . . . we wish to know when we might have our expectations realized."[19]

Unknown to the Chippewa, American authorities were already moving to arrange a cession of portions of their lands. That February the Senate had directed the Executive Branch to arrange a purchase of tracts north of the Wisconsin River. Seen from Washington, the aim was to obtain control of the shores of Lake Michigan and the Upper Mississippi, both to make the whole course of that stream the "barrier" between Indians and the organized states and territories and to gain legitimate access to the vast pine forests of the region.[20] The latter represented a legislative response to the growing demand for pine lumber to build the proliferating new towns of the Mississippi Valley, a demand that had far outdistanced the supply of reasonably priced lumber shipped from western New York and Pennsylvania. Moreover, on the edges of the Chippewa's pine forests proper, a coterie of long-resident entrepreneurs, recognizing a profitable new market when they heard of it, were already maneuvering to obtain private control of these valuable Chippewa resources. These were the old-line principals in the fur trade, the heirs and assigns of the dismantled American Fur Company, as well as smaller independent traders, led by such notables as Hercules L. Dousman, Samuel C. Stambaugh, H. H. Sibley, William Aitken, and Alexis Bailey.

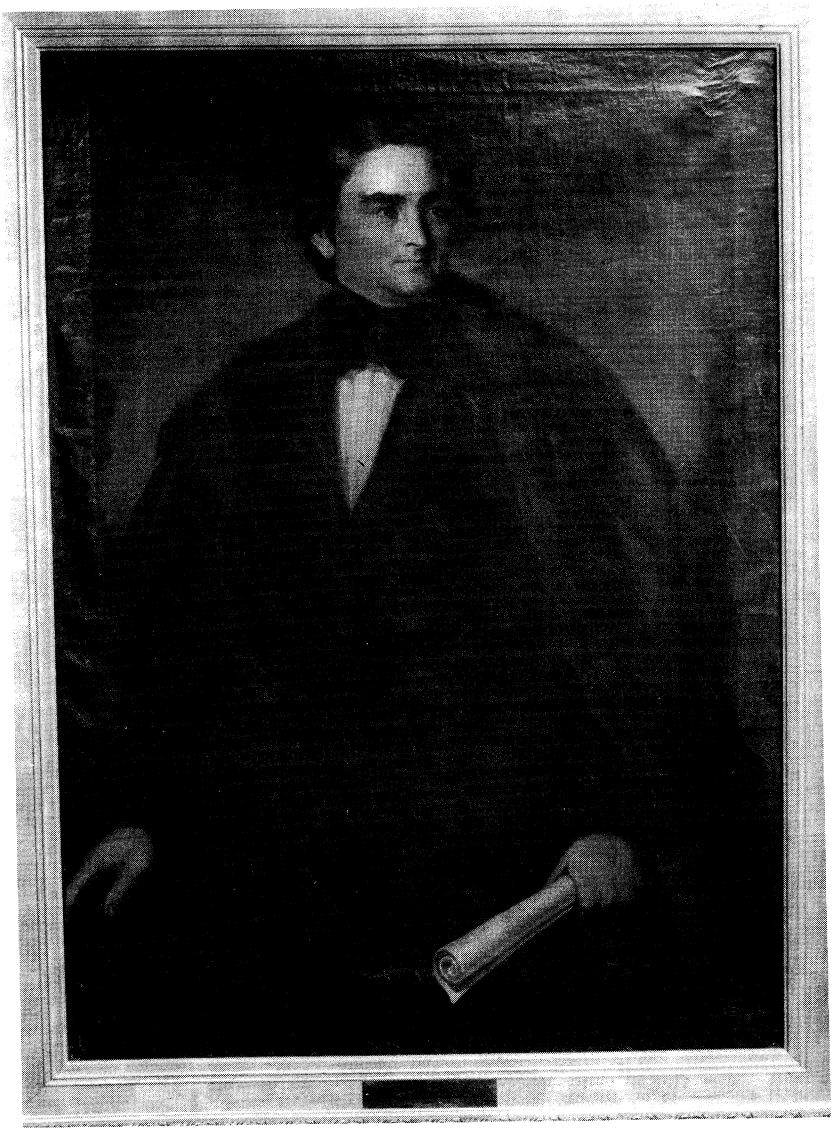
For a number of years, these experienced local residents had been exploiting their personal ties among the Chippewa and other tribes, obtaining from them leases for sawmill sites and timber cutting rights in "Indian country."[21] Operating in the gray areas of Federal Indian law, their activities were scarcely slowed by an imperative directive from the Commissioner of Indian Affairs prohibiting such

private contracts. In early 1837, the Commissioner dispatched a trusted investigator, Major Ethan Allen Hitchcock, to evaluate the situation. He reported that water-power sites and locations for dams and impoundments along the streams in the pinery region, vital for timbering, were few in number. Hence, unregulated, the American Fur Company's successors could quickly obtain exclusive control of timber resources, which would block broader development of the region. From Fort Snelling, Agent Taliaferro reinforced Hitchcock's reports, emphasizing—so he claimed—the opposition of these entrepreneurs to government interests and the growing antagonism of the Chippewa to them. Later, Wisconsin's territorial governor, Henry Dodge, expressed additional reasons for defining a serious threat in the efforts of this cabal: they were, he charged, loyal to British interests.[22] Thus, in addition to the concern with maintaining the government's ascendancy in managing Indians and the need to promote extraction of pine timber vital for regional development, two Jacksonian specters hovered over the preliminaries to the Chippewa's first land cession: the threats of private monopoly and of increased British incursions into the economy of the Northwest frontier. Underneath, however, the real threat was one of old-resident, locally influential individuals to the established Democratic patronage system, interests that threatened the flow of political benefits to the faithful.

In May, 1837, Governor Dodge received instructions for this first Lake Superior Chippewa land sale. Therein the Commissioner of Indian Affairs narrowly emphasized to him the importance of acquiring the pine lands but forbade recognition of any existing private leases for lumbering, which in the end only provoked a land-rush for key sites even before the treaty was ratified (Fig. 1).[23] Although a comprehensive national removal policy was then being implemented, no hint of such a provision was contained in these instructions or expressed during actual negotiations. On the contrary, Governor Dodge was directed to press for use of the proceeds for long-term local Chippewa social and economic development on their remaining lands in Wisconsin and Minnesota and to determine whether the western Chippewa bands would allow the United States to resettle the Ottawa and Chippewa of Michigan among them. From the perspective of Washington and the officials of Wisconsin Territory, there was yet no need to bring about the dislocation and westward "removal" of these Chippewa bands. Instead, they were expected eventually to resettle voluntarily among their kin to the north and west.[24]

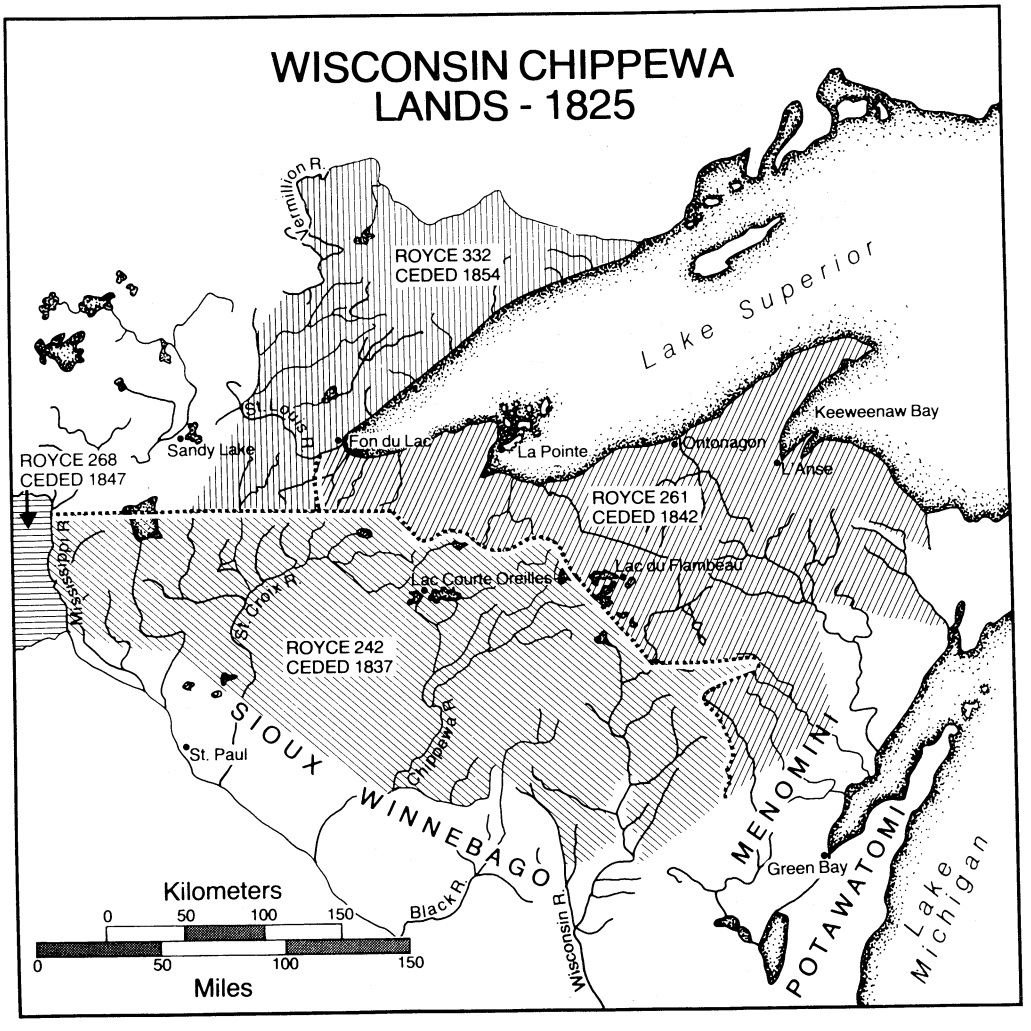
Practical arrangements for this parley created immediate and long-range problems. Since the Lake Superior Chippewa had been in an administrative never-never land (their villages were located between and remote from the Indian agencies at Sault Ste Marie and Fort Snelling), they had never been effectively served by any Indian agent.[25] The latter place was convenient to Governor Dodge's offices in Mineral Point, close to the Mississippi River traffic-way in extreme southwestern Wisconsin. But his selection of Fort Snelling as the treaty grounds placed arrangements for the meeting in the energetic hands of Agent Taliaferro. Taliaferro was rarely slack in promoting the interests of Indians within his jurisdiction—in this instance the Chippewa bands of the Upper Mississippi—nor reluctant to thwart the influence of his rival at the Mackinac Island-Sault Ste Marie Agency, Henry R. Schoolcraft. Thus from the start, the Mississippi bands, only a small fraction of whose lands were involved in this negotiation, were administratively much favored.

The second cluster of Chippewa in-



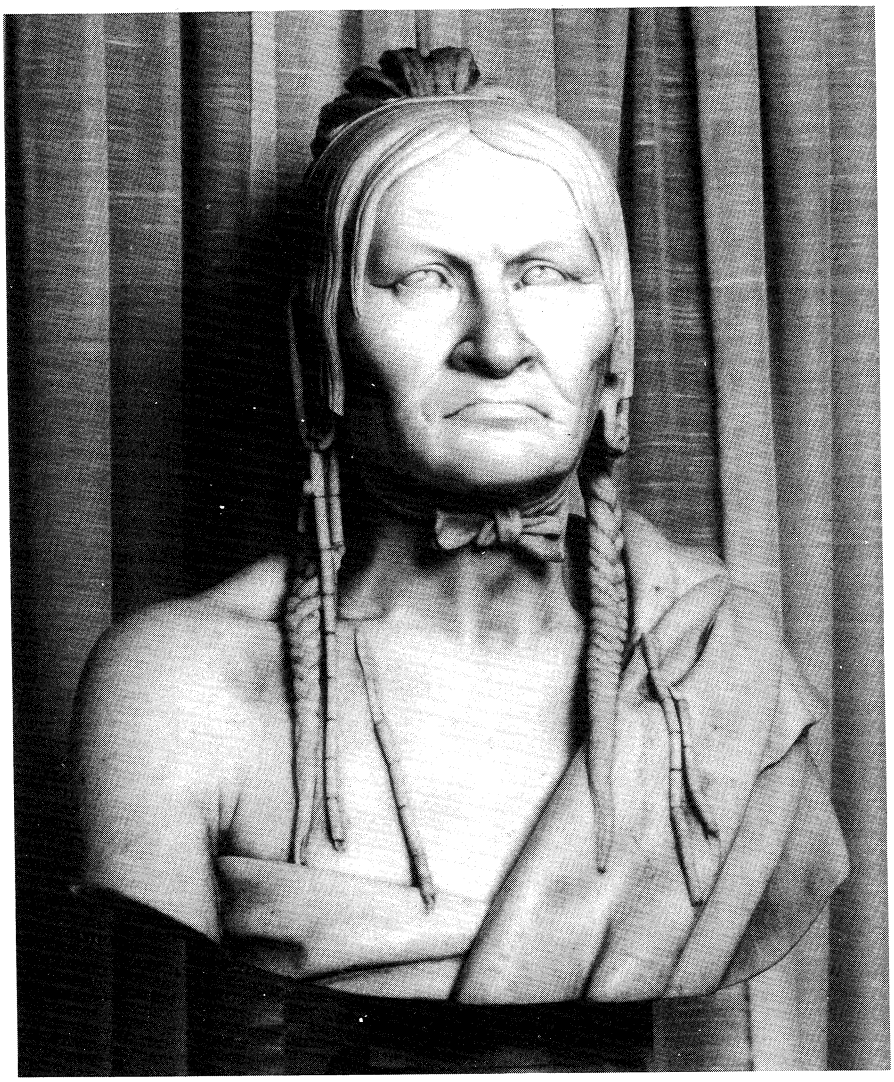
Henry Dodge. When governor of Wisconsin Territory in 1837, Henry Dodge negotiated the Treaty of 1837, and later defended the Chippewas' rights under the 1842 treaty to occupy and to exploit their ceded lands for "many years." Courtesy of the State Historical Society of Wisconsin.

volved were from bands on the Lake Superior shoreline, and none of their lands were ceded that year. Lastly came the interior Wisconsin Chippewa of the Mississippi River's eastern watershed, whose lands were on the block that summer. These interior bands did not receive an official announcement of the treaty, and few of their leaders arrived at Fort Snelling in time to participate in or benefit immediately from the arrangements. This happened because neither of the two newly appointed sub-agents dispatched to carry word of the meetings—Miles M.



Vineyard from Crow Wing above Fort Snelling and Daniel P. Bushnell from La Pointe—visited the interior Wisconsin bands. Indeed, a year later Bushnell still hardly knew the locations of the bands he served or the boundaries of his sub-agency.[26]

Although in earlier treaties the Chippewa had been identified as a "tribe," the treaty sought at the confluence of the Mississippi and St. Peter's rivers in July 1837, was negotiated with a new, American-conceived political-administrative fiction, the "Chippewa Nation." The use of "nation" did not denote any sense of political sovereignty. Instead it was used as a means of dealing with the several Chippewa bands collectively. This novel appellation allowed American authorities to negotiate with some of their delegates as if they represented all and to treat the whole of the lands they occupied as a "national" estate, a concept alien to traditional Chippewa thinking. But while the leaders from the bands on the Lake Superior shore demurred, on the principle that the tract being ceded were not theirs to sell, the powerful chiefs from the Mississippi bands made no attempt to disabuse American negotiators of this



Chief Buffalo (Psheke). Old Psheke of La Pointe, the senior leader and speaker of the Lake Superior shore line Chippewa bands, led the opposition to resettlement in the west and the drive for reservations in Wisconsin. The marble original of this portrait bust was carved from life by Francis Vincenti in Washington, 1855. Chief Buffalo was then about ninety-six years old, and he died later the same year. Courtesy of the Architect of the Capitol, Washington, D.C.

misconception. Indeed, since they had little to lose and much to gain, they dominated the proceedings, intimidating their kin from east of the Mississippi. The few leaders from interior Wisconsin, whose lands were being disposed of, arrived late and scarcely raised their voices.[27]

On the American side of the conference table, although instructed to obtain an outright sale of the whole region, Governor Dodge repeatedly said he wanted only control of the pine forests. Recognizing an opening when they saw it, the Chippewa instructed their official speakers,

Magegabow (The Trap) and the elder Bugonageshig (the elder Hole in the Day) in their reply.[28] On July 27, Magegabow, in flowery words embellished by symbolic gestures, tried to communicate the Mississippi bands' chiefs' interim negotiating position. The Chippewa, he proclaimed, would sell the particular lands wanted by Americans, but they wished "to hold on to a tree where we get our living, & to reserve the streams where we go to drink the water that gives us life." The Secretary recording these debates, Verplanck Van Antwerp, was nonplussed, noting in the margin of the minutes, "This of course is nonsense . . . I presume it to mean that the Indians wish to reserve the privilege of hunting, fishing, etc. on the lands." Clearly, this was not the American intention. Just as clearly, the Chippewa leaders understood their adversaries' aims of acquiring clear ownership of the whole tract.

Meanwhile, Magegabow continued, laying an oak bough on the table before Governor Dodge and saying, this is "the tree we wish to reserve. . . . It is a different kind of tree from the one you wish to get from us."[29] Although these Mississippi bands' spokesmen had no direct interest in the lands being sold, they were declaring their willingness to sell pinelands (useless to them) and their desire to reserve from the sale the deciduous forests and the waterways, which were of particular value to the interior Chippewa as the game-poor coniferous forests were not. Certainly the Mississippi bands' leaders understood the American aim to purchase the use and occupancy rights to the whole region outright, for the governor had repeatedly explained this both before and after Magegabow's speech. What they were doing was hedging, inserting a qualification into the official record, one they could later use to dodge undesirable ramifications of the agreement or to reopen negotiations.[30]

The participating Chippewa finally approved an outright sale of the whole tract. Notably, no mention of removal from the lands was inserted into the agreement; neither had there been any discussion of this matter. Instead, the treaty awarded the Chippewa the temporary privilege of residing on and taking their subsistence from the habitat ceded, "during the pleasure of the President." With these words the Senate delegated to the executive branch the necessary authority to determine when, in the future, Chippewa rights to occupy and to exploit the pine lands should end. Certainly, the Chippewa, at the time, construed these expressions to mean a very long time. Since they could see few Americans in their lands and since it was to be years before their basic adaptations were much disturbed by aliens there, they had no reason to think otherwise. Indeed, American officials at the time expressed no definite ideas about when this privilege would be withdrawn.

However, an eyewitness to the negotiations recorded a foreboding judgement about the "pleasure of the President" phrasing, not about the timing, but about the way this privilege would ultimately be withdrawn. Writing to his superior in Boston, missionary W. T. Boutwell predicted "trouble with the Chipys. before five years should they attempt to remove them . . . the Inds. have no idea of leaving their country while they live—they know nothing of the duration of a man's pleasure."[31] An experienced observer of Chippewa ways, Boutwell was commenting on several social facts. The scattered, politically decentralized Chippewa, especially those in Wisconsin, would not feel themselves bound to contracts made by distant chiefs not their own, and they would likely resist a later order to abandon the ceded lands issued by any remote authority figure such as the President.

But so far as American authorities were concerned, a firm agreement had been

reached: the lands wanted had been acquired by outright purchase, while continued Chippewa use of the area was impermanent. So, too, were realized certain of the "expectations" expressed by Flat Mouth the previous year. Those Chippewa at the treaty grounds received a modest amount of goods, and the bands later got the benefits of a substantial twenty-year term annuity. For a time the annual payments—whether goods or money—were shared among some of the constituent bands of the fictive "Chippewa nation," especially those from the Upper Mississippi and from interior Wisconsin. Although few of the latter had participated in the negotiations, after protesting the next year, they finally accepted the treaty's terms when assured they would share in these annual payments.[32]

The Lake Superior shoreline bands, however, by their own choice were excluded from the annual compensation. Nonetheless, a few of the latter were soon issuing complaints like those of Flat Mouth in 1836, expressing envy of those bands who were receiving payments from the United States and indicating a disposition to sell additional lands in exchange for annuities. Some American authorities, too, were concerned with this disparity, particularly because the lakeshore Chippewa still regularly visited British posts to receive "presents," stipends supposedly "5 times" greater than the annual per capita payments from the 1837 treaty.[33] Meanwhile, in the interior, the lumber rush was on. Hardly had the treaty been signed when the old resident entrepreneurs, whose maneuvers had helped precipitate the cession in the first place, flooded into the pine lands, there preempting prime mill sites and timber tracts well before the treaty's ratification, land surveys, or public sales.

The resentments of Lake Superior-shore Chippewa were exacerbated by a decision reached by American authorities. Although the large, long established traders lobbied for Fort Snelling or—ominously—Sandy Lake, as the point of distribution for annuity goods, and while the Chippewa recipients themselves preferred several locations convenient to their villages, the Office of Indian Affairs fixed on La Pointe as the one place where the Chippewa had to gather yearly to take delivery of their treaty dividends. Therefore, for several years the lakeshore bands had to stand by and watch as those from the west and south assembled amidst them to receive payments. Certainly, significant parts of the goods and money delivered initially to the visiting Chippewa delegations quickly flowed, through long-established kin ties and reciprocal exchange networks, into the hands of the Lake Superior hosts. But this could not have satisfied the chiefs of the lakeshore villages, who witnessed their counterparts, especially the notably imperious and ostentatious leaders of the Mississippi bands, receive recognition and rewards denied to them. Thus more fuel was added to a growing discord, which soon pitted all Wisconsin Chippewa against those from the Upper Mississippi.[34]

However, at the time, no one recognized the truly hazardous economic transformation then emerging. For many decades, these Chippewa, as specialized winter trappers, had been involved in flexible, personalized, predictable exchange relationships with individual traders. Now they were collectively dependent on a complex, ill-organized, impersonal federal appropriation-purchase-transportation-accounting-delivery system, a cumbersome arrangement that rarely brought payments due to a place on a date compatible with their own seasonal subsistence work. Over the next decade the Chippewa learned that this system seldom worked satisfactorily: long delays and interference in late fall wild-rice gathering and winter hunting, not to mention the

costs of long distance travel to the payment grounds, were the rule. On the other hand, there were unanticipated benefits from the treaty. As the clear-cutting of pine forests progressed, the size of the ecotone—the pine forest-prairie "edge" where white-tailed deer flourished—was vastly increased. Since deer were the most desirable and the prime source of food for the interior Chippewa, as the size of the herds increased the subsistence value to them of the lands they had ceded was also enhanced. This ramification was precisely contrary to standing American preconceptions: that the advance of "civilization" would cause a decline of available game and the voluntary migration of the "primitive Indian hunter."[35]

Nonetheless, although the issue had not been raised during the 1837 negotiations or by the Senate in ratifying this accord, Indian removal was in the air, for the resettlement of Indians from other parts of the Old Northwest was then being pressed vigorously. In response to rumors of such dislocations and reactions from the Chippewa, local Indian agents regularly advised their supervisors that the Lake Superior Chippewa would resist this threat with all means available to them. There was, simultaneously, little or no indication from neighboring citizens that moving the Chippewa was a desirable tactic.[36]

But these Chippewa had to cope with the real danger of treaty stipulated resettlement in the west during September, 1842. That month the same three clusters of bands that had negotiated the 1837 agreement gathered at La Pointe to debate a second cession, this one involving all remaining Chippewa territory in Wisconsin and Michigan's Upper Peninsula. Again the Americans sought, not agricultural lands, but control of a valuable natural resource, the copper-ore rich tracts along the Lake Superior shoreline.[37] The treaty dealings at La Pointe were in striking contrast to the 1837 council. At the earlier sessions, negotiations were, by the standards of the day, conducted in an open and aboveboard fashion, despite some manifest miscommunication and confusion. In 1842, the meetings provoked angry discord between opposed parties and a lasting controversy.

Before the final 1842 treaty document was signed, the chief American negotiator, Robert Stuart, had to engage in a variety of tricky tactical moves and coercive threats to force through an agreement. Moreover, to secure the consent of the parties most imperiled—Wisconsin's interior and the Wisconsin-Michigan Lake Superior shoreline bands—he had to issue firm verbal commitments, explicit stipulations not written into the formal agreement. Stuart (long a senior agent of the American Fur Company, recently appointed to succeed Henry R. Schoolcraft as head of the Mackinac Superintendency) faced an unusually complex and contentious situation. In addition to his duty to the United States, he had firmly in mind the fiscal needs of his former employer, John Jacob Astor. Moreover, he confronted an unruly assembly of diverse and generally opposed interests: old trading firms and newly established ones, several denominations of missionaries, mining entrepreneurs, the culturally marginal "half-breed" community, commercial fishermen, and—by no means the least divided or quarrelsome—the Chippewa themselves.[38]

The latter were now separating decisively into two divisions, those from the Upper Mississippi, and those who occupied the lands ceded in 1837 and the tracts to be sold at this meeting. Moreover, because control of the last of the Chippewa's Wisconsin lands was at issue, all involved were possessed of more than the usual windfall mania, which often stimulated dramatic confrontations at Indian treaty proceedings during this era.[39]

Thus in October the parties gathered in a variously expectant, threatened, or angry mood. Most of them, "who otherwise before-time was but poor and needy, by these windfalles and unexpected cheats" eagerly anticipated obtaining some benefit, security if not wealth.[40] They milled about for days and nights eager to shake free of the great treaty tree—each in his own direction—some of its perennial fruits.

The instructions Stuart received from Commissioner Thomas H. Crawford were of a sort to vex or inflame most of these interest groups. He could allow no payment of traders' claims on the treaty grounds, a provision subsequently softened. Neither personal reservations for half-breeds or "friends" of the Indians, nor band reservations for the Lake Superior Chippewa were allowed. Most important for the future of these Indians was the unyielding two-stage requirement for their dislocation and resettlement. Those Chippewa immediately affected offered no opposition to the first of these, the plan for their immediate abandonment of those particular tracts containing copper ore. Neither did they oppose the cession of nearly all their remaining lands. They demanded, however, several small band or community reservations, both within the area ceded in 1837 and the lakeshore region now on the table for disposition.

Stuart's instructions about the removal provision, however, were firm. The Chippewa would have now to agree one day to abandon the land sold and to resettle in the remaining "national" lands west of Lake Superior, that is, in the territory of the rivals, the Mississippi bands. But the Commissioner of Indian Affairs had stressed, and Stuart in council repeatedly emphasized, that this second step migration would not be required for a "considerable time," not until "policy" required the President to call for their relocation.[41]

On that issue—the timing of their resettlement—the fate of the negotiations hung. While Stuart readily disposed of the traders' demands and those of the half-breeds, the removal issue so threatened the Wisconsin bands that they resisted obstinately. It was then that Stuart resorted to a heavy-handed deception, claiming that the Chippewa had already ceded the mineral tracts in 1826, an allegation that the Chippewa delegates (and their American allies) denied. Ultimately, to obtain substantial support for the treaty from those nominally in control of the lands, he introduced a decision-making novelty—majority rule. The lakeshore and interior bands, relying on the traditional requirement of a consensus, were thereby outmaneuvered. Unaffected by the cession or the removal provisions, and in line to reap yet more benefits at no cost to themselves, the eager chiefs of the Mississippi bands quickly gave Stuart their "votes." They had no more intention of welcoming the Wisconsin Chippewa into their lands than the latter had of moving there. For entirely different reasons, so, too, did the small Catholic and Methodist mission communities on the Keweenaw Peninsula cast their "votes" for Stuart's proposals. This minority of christianized Chippewa believed that they could avoid removal by becoming landowning, tax-paying, farming citizens of the State of Michigan.[42]

Even so the Wisconsin bands balked and protested. Stuart then inserted into the oral record a critical clarification and stipulation. Yes, he and the Chippewa soon agreed, they would immediately have to give up occupancy and use of the copper ore tracts proper. Additionally, some day in the future the President would likely require the Chippewa to abandon all the lands being ceded and to settle elsewhere. The question pressed by the Chippewa chiefs was—when? In the distant future, replied Stuart. Be more

Robert and Elizabeth Stuart. When the Wisconsin Chippewa were pressured to leave Wisconsin in the mid-1840s, Superintendent Robert Stuart defended their right to remain for fifty to one hundred years, an explicit commitment he had made while negotiating the 1842 treaty. Courtesy of the State Archives of Michigan.

specific, demanded the suspicious chiefs. Not during your lifetimes, nor those of your children, not for fifty to one hundred years, were Stuart's phrasings as recorded by different observers. Indeed, Stuart himself later repeatedly defended the rights of these Chippewa under such mutual understandings when others violated the explicit assurances this tough-minded Scot had publicly given.[43]

Nonetheless, although most of the Wisconsin chiefs then capitulated, several remained unbelievers and refused to place their marks on the treaty document. In this manner was created the basis for a later, prolonged, unresolved dispute over the meaning of the 1842 agreement, a controversy over the issue of timing of Chippewa removal, the first necessary ingredient for the trouble that erupted eight years later. This controversy raged over what the Chippewa and their supporters (including Stuart) saw as premature demands for these Indians to move. No further condition, such as the Chippewa's "continued good behavior," had been discussed during the debates over terms, nor was any such condition mentioned in the years immediately following.[44]

However, for more than a year before the 1842 treaty, a few key actors in Wisconsin Territory had regularly misinformed authorities in Washington to the effect that the Chippewa were eager both to cede their lands and to resettle west of Lake Superior. Together with his allies, Governor James D. Doty—who had strong personal and political interests in developing the new Northern Indian Territory in Minnesota and the Dakotas—was first among these promoters.[45] Superintendent Stuart, following his first visits to his new charges, particularly after his exertions in extracting a land cession agreement from them, knew better. When the few advocating Chippewa removal continued their efforts, Stuart stood in opposition, arguing he had personally and officially promised them no removal for many years. Of greater practical importance, he pointed out, there were no obvious incentives for the Chippewa to make this move, for they had ample supplies of fish, game, and wild rice in their present locations and were experiencing few problems with the influx of Americans in the region.[46] In addition, the Wisconsin bands were by no means eager to settle among those on the Mississippi, who twice had been deployed against them to their disadvantage, especially because they knew that the remaining part of the "national" estate was an impoverished area.

Chippewa resistance to removal was reinforced because, as they understood the 1842 treaty, they could not be obligated to give up use and occupancy of the ceded lands for many years, and this construction was championed by numerous Americans directly familiar with its negotiation. Similarly, the tactics used against them in the 1837 and 1842 negotiations had led to increased solidarity between Wisconsin's interior and lakeshore bands. Facing a common threat in their politically altered environment, they began responding with better coordinated opposition. Prompt organization of their dissent was imperative, for within a year following the treaty, new pressures developed for their immediate dislocation. Despite the early opposition of Superintendent Stuart, Commissioner of Indian Affairs Crawford, Governor Dodge, and others, who variously argued that immediate removal was against the spirit of the treaty expressed in explicit verbal stipulations or that it would not benefit the Chippewa, this pestering continued and increased in strength. Wisconsin Chippewa opposition came into clear and successful focus in 1847, when the United States made an abortive effort to secure the cession of the mineral-rich north shore of Lake Superior.[47] Knowing how much Americans valued control of that region, the Wisconsin Chippewa used as a bargaining token their rights to this—for their economic purposes—barren landscape. Without a treaty-guaranteed right to remain in Wisconsin, the Chippewa would have nothing to do with negotiations for the cession of the north shore, which they managed to block until 1854, when their demands for reservations were finally met.[48]

When efforts to talk the Chippewa into

migration continued following the unsuccessful 1847 treaty councils, these communities stepped up their political opposition. Meanwhile, they proceeded along self-defined paths toward economic improvement in place, irrespective of what views American authorities held for their future. Then, in early August, 1847, Commissioner Medill signaled the preliminary design for their removal. The La Pointe sub-agency was to be closed, its functions shifted west of the Mississippi to Crow Wing even if efforts to secure the north shore of Lake Superior were unsuccessful. In the latter instance, relocation of the La Pointe sub-agency and its services, so believed the Commissioner, would have the effect of luring some Wisconsin Chippewa west, easing the way for the removal of the remainder. Later Medill explained the government's plans for resettling all Wisconsin Chippewa that coming spring to R. Jones, Adjutant General of the Army. The Chippewa were not alone in Medills design: the Menomini, Stockbridge, and those Winnebago still in Wisconsin (then near statehood) were also targeted, together with the Winnebago in the old "Neutral Ground" in the northeastern part of the new state of Iowa. Together, these several relocations were designed to clear Wisconsin, Iowa, and southern Minnesota of their remaining Indians, leaving a broad corridor open for American movement westward, between the existing Indian Territory southwest of the Missouri River and a viable new Northern Indian Territory in north-central Minnesota.

While these distant plans were being laid, the Lake Superior Chippewa followed their own variegated agenda of economic adaptation. The 1842 treaty had added a second valuable term annuity to their annual income. Over the course of twenty-five years, they would share with the Mississippi bands yearly an additional $12,500 in coin, an equal amount in hard goods, rations, and consumables, and over $6,000 for the services of blacksmiths, farmers, teachers, and other artisans. But this was only a small fraction of their annual needs, so these Indians proceeded to make up the balance by their own enterprise. Fur- trapping continued to be of small importance, while on the lakeshore, Chippewa men were increasingly engaged in commercial fishing, either with their own equipment or as seasonal labor for Americans. As mining developed, numerous Chippewa men transported supplies, acted as guides, cut and supplied mine timber, or delivered venison and fish. Intensive gathering went on, and gardening increased, particularly of root crops; this was largely the work of women, who traded surplus vegetable foods and otherwise served the mining crews. In the interior, where the timber industry was expanding along the lower river valleys, similar changes in economic behavior occurred, attuned to the labor and material requirements of that extractive industry.[49]

Some few Chippewa, particularly those on the Keweenaw Peninsula, as well as at the Reverend L. H. Wheeler's experimental station at Bad River, even approximated the old expectation of ill-informed American philanthropists by engaging in sometimes productive, male-managed, animal-powered small farming, although most others strongly resisted this novelty, risky at best in these latitudes. The substantial development, notably, lay in individual wage work and small-scale commercial enterprise, primarily in extractive industries, not in agriculture. But of greater long-range importance was the growing recognition among the local American population—most of whom were entrepreneurs, managers, or laborers, nearly all male, not under-capitalized small farmers with families seeking cheap land—that the Chippewa were delivering services and goods important to their

enterprises. The Chippewa were creating tight social and economic bonds with potential allies in their immediate neighborhood.[50]

Thus, by early 1848 one necessary antecedent of a high stress, forced relocation was firmly in place: there was a prolonged, irresolvable dispute between Chippewa leaders and American national authorities over the right of the latter to demand and enforce abandonment of the ceded lands. Since Wisconsin's statehood was imminent and its laws would soon be extended over the area inhabited by the Chippewa, Commissioner Medill made a firm decision: they would have to leave. When rumors of government planning for this step reached the Chippewa they responded with a variety of political counter-moves. Some started asserting their "right" to reservations, claiming these had been promised during the 1842 negotiations.[51] But planning for relocation went on, with the 1849 establishment of Fort Gaines (in 1850, renamed Fort Ripley) on the upper Mississippi, and the reshuffling of agents and agencies aimed at concentrating the Chippewa on their remaining "national" lands in northern Minnesota. Chippewa opposition hardened as well, expressed in systematic lobbying in Wisconsin, Michigan, and Washington for the right to remain on small reserved parcels within the bounds of their old estate. A few on the Upper Peninsula, aided by their missionaries, started preempting and purchasing public lands, thereby acquiring the status of taxpaying citizens under state law.[52] Meanwhile, others sent delegations to plead their case in Washington.[53]

The Chippewa delegations to the nation's capital did not find an attentive reception, for throughout 1849 and 1850 Congress and President Taylor were preoccupied with larger issues such as incorporating the far West into the American state and the associated crisis regarding the extension of slavery in new territories. Nevertheless, despite the unconcern with the desires of several thousand Indians in an already established Free State, various political-administrative developments combined to create a national and a local context for what Methodist Missionary John H. Pitezel, an eyewitness on the Lake Superior scene, subsequently called a "chain of distressing evils."[54]

President Taylor's patronage sweep through the positions controlled by his office created the official team directly responsible for the Chippewa's winter disaster. Since the Indian Office had been transferred to the new Department of the Interior, relations with these Indians were brought under the supervision of a Taylor loyalist, Thomas Ewing of Ohio, a man more concerned with problems of the distant West than with those in northern Wisconsin. Secretary Ewing, however, strongly favoring the trading firms, kept a firm grip on the details of managing the Indian business, causing the new Commissioner, the Kentucky Whig Orlando Brown, much frustration. The third member of the administrative chain responsible for arranging the attempt to move the Chippewa out of Wisconsin was the Pennsylvania Whig, Alexander Ramsey, who in March, 1849, was appointed Governor and Superintendent of Indian Affairs in the newly formed Minnesota Territory. This trio had little experience in the management of relations with Indians, but the team was not yet complete. It was awaiting its fourth, junior but key, member, Sub-Agent John S. Watrous.[55]

Until this time, the relocation of the Lake Superior Chippewa had been little more than an administrative intention; no specific mechansim for accomplishing this aim had been created. Neither had there been an immediate impetus for translating thoughts into deeds. Excepting the Lake Superior shoreline and the river valleys

traversing the pine lands, most of the ceded Chippewa lands were entirely unpopulated by Americans. The fact that the Americans residing nearby were almost entirely male likely reduced rather than increased local support for removal. However, there was simply too little "settlement" anywhere to create local "pressure" for removal.[56] In addition, although they adamantly held to their right to remain in Wisconsin, the Chippewa had not forced the dispute to a confrontation point. Instead, still holding title to the north shore mineral lands, they remained pacific and reasonable, employing lobbying and bargaining tactics, seeking approval for reservations within their old estate.

The thrust, but not an explicit mechanism of Chippewa removal, derived from the appointment of Governor Ramsey, who was the titular head of the Whig party in Minnesota Territory as well as Governor. Being one of the few Whigs in a frontier Democratic stronghold and expected to deliver economic favors to party loyalists, his position in this new Territory was particularly difficult. Thus, concerned with patronage and with establishing a firm presence in his new office, when counseled by a powerful Minnesota trader, H. H. Sibley, Ramsey could see that the Wisconsin Chippewa presented an opportunity. Obtaining their removal meant also transferring their large annual annuities and the numerous salaried jobs associated with their management into his superintendency. As well as moving an important patronage resource out of a Democratic state into his hands, the resettlement would also have meant a policy coup, a major step toward rejuvenating the floundering plans for a Northern Indian Territory.[57]

The April 22, 1850, appointment of John S. Watrous as the new Chippewa sub-agent added a critical figure, a man with at least some experience in the region and among these Indians, and one with a profound vested interest in seeing them dislodged. Originally from Ashtabula, Ohio, Watrous had arrived at La Pointe in 1847 hoping to make his fortune in the Indian trade, in which he was unsuccessful. Something of a political chameleon, in early April he left his desk in the Wisconsin State Assembly—where he had briefly served a Democrat constituency in the northwestern part of the state—to travel east in search of greater opportunity, likely drawn there by news of the Presidential order revoking the Chippewa's 1837 and 1842 treaty privileges. In Washington he presented himself to influential friends of his family as a staunch Ohio Whig and as a man experienced in dealing with the Chippewa.[58]

Watrous was a man with plans—for himself and for dispossessing these Indians. He was soon dispatched to his new post carrying Commissioner Brown's official, public orders to bring about the immediate movement of the sub-agency into Minnesota Territory, as well as a covert scheme for dislodging the reluctant, wary Chippewa. Thus was combined an ongoing dispute over a treaty and several influential local actors—men with vested interests in securing a removal. A potential disaster lay waiting only the major confrontation that the Chippewa had been avoiding. Guided and supported by his superiors in the administrative hierarchy, particularly by Governor Ramsey, Watrous soon manufactured this confrontation.[59]

The public version of these plans specified a summer, 1850, timing for the relocation. However, aside from closing down the sub-agency's operations in Wisconsin and Michigan's Upper Peninsula, Watrous did little to bring about the move that early. Indeed, there is no suggestion anyone believed the Chippewa would cooperate had such an attempt been made.[60] Aside from Ewing, Brown,

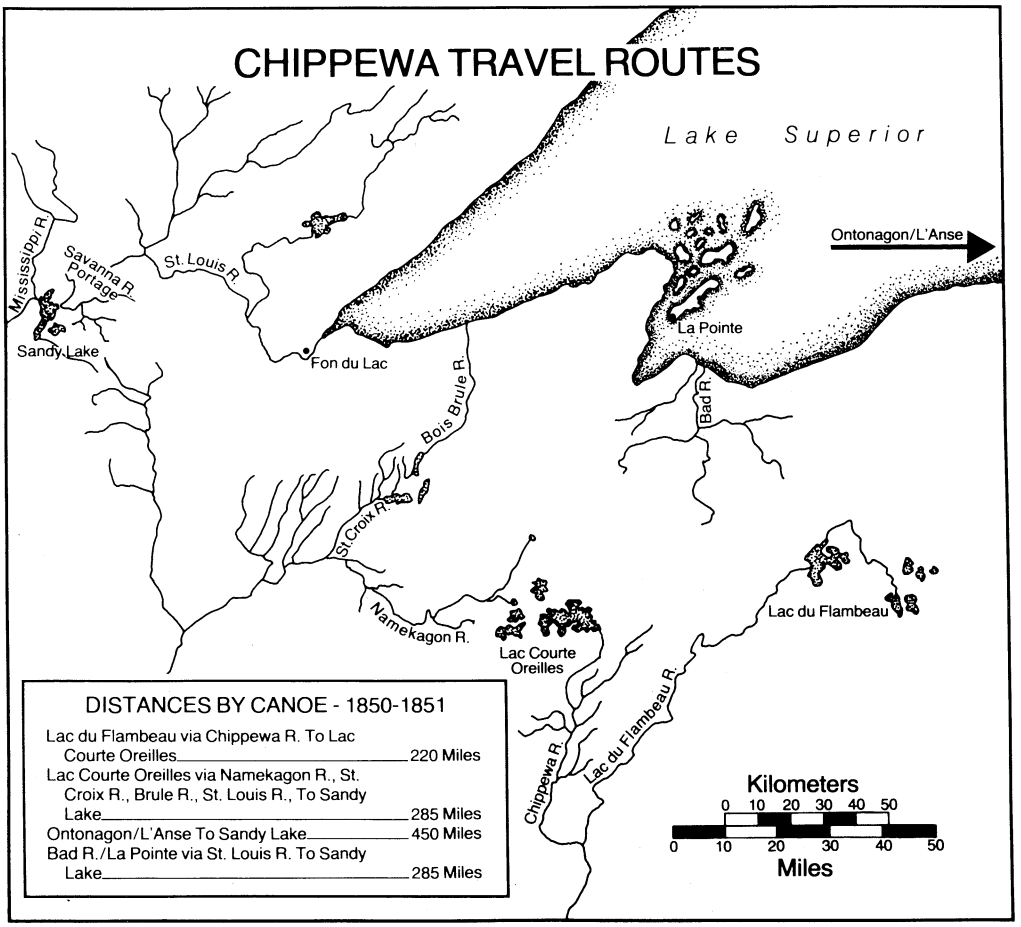
Ramsey, and Watrous, few if any others knew of the covert, contingency design, timed for a tricky, hazardous, early winter dislocation. In any respect, news of the President's executive order withdrawing the privilege of occupying the ceded lands spread rapidly, and the reaction was equally swift. While the Chippewa and their American allies began mobilizing for political resistance, there was also much demoralization. Of those who had been farming, many would not plant crops that spring; many more spent long periods in councils debating how to avoid resettlement. The time and energy spent in political agitation and the wasted economic inactivity resulted in decreased food production that summer and fall. The Chippewa became even more dependent on government rations, which contributed to the winter debacle.

Protestant and Catholic missionaries associated with the Indians were divided in their reactions. Being largely dependent on federal funds for their operations, they had to tread lightly; the position most commonly expressed was one of ambivalent neutrality, and none rose to a heroic defense of the Chippewa. On the one hand, they deferred to presidential authority; on the other, they had to consider what they saw as their responsibilities to the Chippewa, which were, mainly, to see to the future of themselves and their schools and missions among the Indians. Most commonly, while not actively supporting or opposing relocation, they would not counsel the Indians to move or stay.[61] In the end, only a few became active advocates of resettlement. The Reverend Sherman Hall at La Pointe was one. Soon after taking office, Watrous acquired Hall's loyalty with the promise of an important job at the proposed new Indian boarding school in Minnesota.[62]

However hesitantly, soon some missionaries quietly began aiding the Chippewa in framing their petitions and helping to mobilize help from other Americans in the region. One active and effective supporter was Cyrus Mendenhall, a mining entrepreneur associated with the Methodist Episcopal Mission Society, who on an inspection trip along the Lake Superior shore in June, 1850, circulated a memorial among Americans calling for the recall of the removal order. Most merchants, mine foremen, lumbermen, and other influential citizens between Sault Ste Marie and La Pointe responded to Mendenhall's appeal, which was subsequently delivered to Congress and officials in Washington. Mendenhall kept up the pressure and was soon joined by the Reverend S. B. Treat (Secretary of the American Board of Commissioners for Foreign Missions). Their lobbying effort grew in force and did not end until after removal order was withdrawn two years later.

Indeed, from the start there was no evidence of local public support for the Chippewa's removal. Regional newspapers, echoing and reinforcing the sentiments of their readers, regularly criticized the President's order and both the motives for and the tactics employed in efforts to implement it. Sault Ste Marie's *Lake Superior News and Mining Journal* was consistently strident in its support of the Chippewa, and its editorials and news clips were picked up and reprinted throughout the Great Lakes area. The Chippewa even made the news in Boston, when one of their delegations passed through on its way to Washington. The fact that the whole region occupied by the Chippewa was strongly Democratic did not aid the Taylor administration in its efforts to dispossess them.[63]

Meanwhile, Sub-Agent Watrous worked at implementing the public version of his orders. He first conducted an inspection tour of Sandy Lake (Fig. 2), the new site where the Chippewa annuities were to be



distributed. There he began arranging his own future as well, at that profitable intersection between private enterprise and public business. He established a mutually promising relationship with the agents of Chouteau and Company, the St. Louis firm that dominated trade in that area, and with potential contractors, suppliers, and transportation firms in St. Paul. By the end of July, 1850, he enjoyed a freedom of action greater than most Indian agents, for three key figures at the top of the Whig political hierarchy and national administration were gone, with the death of President Taylor and the resignations of Secretary Ewing and Commissioner Brown. Meanwhile, Congress was violently debating the Great Compromise, not mundane domestic matters such as the Indian Appropriation Bill. Thus an unanticipated ingredient was added to Watrous's covert plan—whatever he did or abstained from doing, the vital Chippewa annuity money would certainly be dangerously late in arriving. At the same time, the Chippewa were celebrating what seemed to them a success. Watrous had led them to believe that they had only to come to Sandy Lake—285 to 485 difficult canoe and portage miles to the west—to receive their annuities. Some Chippewa determined to do this, while all understood that they could for many years remain in Wisconsin even if it meant giving up the treaty specified annuities and local services of blacksmiths and farmers.[64]

These Indians and local citizens had no inkling that, earlier in the year, Commissioner Brown had sent Governor Ramsey a different set of orders and a plan, which Watrous, if not himself its principal architect, was certainly aware of before he left Washington in late April. This plan was never made public, allowing Ramsey and Watrous later to deny that a removal had ever been intended during the winter of 1850–1851. The scheme was straightforward. Annuity goods and money were to be paid only to those Chippewa who traveled to Sandy Lake accompanied by their families. These payments were not to be made in late summer or fall, because then the Chippewa would simply return to "their old haunts." Instead, the payments were to be made only after winter had set in, preventing travel by canoe. Someone, most likely Watrous, had advised the Commissioner of the Chippewa's great aversion to overland winter travel. Lured by their annuities, they were to be trapped near Sandy Lake by winter's freeze.[65]

In early October, the Lake Superior Chippewa were informed that both their cash and goods annuities would be waiting for them at Sandy Lake on the 25th of that month, a date already dangerously late in the season, which guaranteed at minimum further disruption of their own seasonal subsistence work. Watrous had by then obtained the goods specified in the 1837 and 1842 treaties and had them, together with a grossly inadequate supply of rations, delivered to Sandy Lake at extraordinarily high prices. Since the new sub-agency's farms were not yet in operation, there were no public food supplies stored at that remote location. Thus, once the Chippewa received their money annuities, they were heavily dependent for basics on purchases from the local traders, since the marshy Sandy Lake region, as well as the route going and coming, were notoriously deficient in game. This deficiency was exacerbated when the upper Mississippi flooded that season, inundating the crude structures where the supplies of both the government and the private traders were stored, spoiling the inadequate amounts of flour and salt pork available, and destroying the local wild rice crop. To compound these sources of nutritional stress, the Lake Superior shoreline Chippewa had a poor fishing season earlier that year and had already experienced grave food shortages.[66]

Constructed in this manner by several key actors with personal and political goals overriding any concern they may have had for their charges, with an assist from uncontrollable natural and institutional events, a tragedy lay in waiting for those Chippewa electing to hazard the long trip to Sandy Lake. Not all the Lake Superior Chippewa accepted the high risks they could see in this dangerous edge-of-winter journey. The bands at L'Anse, Ontonagon, Pelican Lake, and La Vieux Desert refused entirely. Those from the headwaters of the Wisconsin River sent but two men, and the villages on the Chippewa River drainage somewhat more. More came from the La Pointe area villages, but in all these instances the Chippewa took precautions. Ignoring orders to bring their families, they dispatched mainly adult males. Apparently, only from those villages closest to Sandy Lake, on Lake Superior's north shore and on the upper Mississippi, did some family groups make the journey. Moreover, intending to pack the annuity goods for their communities home by canoe and on their backs, these delegations traveled light, without the rolls of birchbark and woven mats needed to sheath temporary wigwams, many even without their firearms. These decisions further contributed to the physiological stress they experienced over the next three winter months.[67]

Those Chippewa bands who sent dele-

gations to collect their annuities coordinated their travel plans. Coming by different routes, they assembled at Fond du Lac before pressing up the difficult portages along the St. Louis River, and then via the Savanna portage to the marsh and bogs surrounding Sandy Lake. Exactly how many made the trip is uncertain. It was likely fewer than 3,000, the figure Watrous later used in boasting of how many he had "removed" that winter. Earlier, he claimed 4,000 had assembled by November 10, but this number included some 1,500 from the Mississippi and Pillager bands, present to collect their annuities, not to be resettled. Watrous never provided his superiors with careful counts or lists of those who arrived, for once confronted with the disaster his actions had caused and the great hostility of the assembled Chippewa, he distributed the remaining putrefying rations and the other goods from the flooded warehouses to those present, disregarding his orders to deliver only to family groups.[68]

Those Lake Superior Chippewa hazarding this journey began arriving at Sandy Lake in mid-October. They discovered Watrous gone and no one present authorized to parcel out the goods waiting for them; he was on his way to St. Louis supposedly to collect the more valuable annuity money. Soon the suffering began—from illness, hunger, and exposure. The sojourners lacked shelter, and most of the scanty supply of spoiled government rations were quickly consumed, leading to an epidemic of dysentery so incapacitating and deadly that American witnesses were certain it was cholera. This was soon accompanied by an epidemic of measles, which further contributed to high rates of illness and fatalities. The Chippewa were concentrated in an unsanitary, waterlogged area, with few natural food supplies available. While they lacked shelter and medical services, were unable to collect their goods, waited day-to-day for the arrival of Watrous to bring their critically needed money payments and to open the warehouses, the Chippewa's health and energy were increasingly sapped by hunger, infectious diseases, and the winter now on them. If some of these components had been absent, they might have scattered, reducing the rate of reinfection. As it was, American witnesses reported that on many days there were eight or nine deaths, so many that the few who were well could not inter the corpses properly.[69]

Watrous saw only the last days of this calamity, for he was absent from his post until November 24, a month later than the promised payment date that had lured the Chippewa west. After sending messages for the Chippewa to assemble, on October 6 he left for St. Louis and arrived there on the 21st, four days before the scheduled payment, then at least two weeks hard travel to the north. In St. Louis he soon learned that no funds had arrived and none were expected that year, information he could easily have anticipated while yet in St. Paul, for the national political crisis had so stalled Congress that for months little attention was given ordinary domestic matters. The Appropriation Bill providing funds for the Chippewa's annuities did not pass until November 12, much too late in the year for the required physical delivery of the specie to such a remote location. Watrous on October 26 finally took passage on a steamer for his return trip, but the vessel was delayed, and he did not arrive at St. Paul until November 13. There he tarried two more days, attending to his own business, mainly pleading to obtain an upgrading of his Sub-Agency and a promotion for himself. He did not leave St. Paul until the 15th, and then the onset of winter forced him to abandon his canoe and travel on foot overland, an ill augury for the sick, starving Chippewa at Sandy Lake, who had been waiting six weeks for their goods and money.[70]

The major unanticipated institutional ingredient adding to the scale of the disaster organized by Brown, Ramsey, and Watrous was the failure of Congress to appropriate funds for the Indian Department in a timely fashion. Without hard cash to purchase necessaries for the winter, the Chippewa—who in addition to the epidemic illness, great loss of life, and their general debilitation had lost an entire season's subsistence production—were in even more desperate condition. However, on arriving at Sandy Lake on the 24th and seeing the consequences of his scheme, Watrous set to work cutting his administrative losses. The idea of trying to keep these sick, starving Chippewa near the Mississippi was swiftly dropped. He then did what little he could to relieve their "pinching wants." After much wrangling over who would be responsible for the unauthorized expenditure, he persuaded the traders to deliver a small quantity of ammunition at a highly inflated cost to the Chippewa for subsistence hunting on their way home. Similarly, he drew up arrangements for the traders to deliver to the Chippewa from their stores $8,368.40 in provisions, an advance against their yet unpaid cash annuity, at what he claimed were "the most reasonable terms possible." The terms were in fact extraordinary, three to six times those of prices at St. Paul and other nearby depots. By Governor Ramsey's own estimates, this amount was barely three days supply of food, entirely insufficient for the Chippewa's arduous return trip.[71]

Finally, on December 3, with winter fully on them, when their scanty rations and goods were at last in their hands, the encampments broke up. The Chippewa left immediately, abandoning two hundred sick and a few well adults to care for them. By then more than a foot of snow lay on the ground and the streams were frozen over, preventing the use of canoes, which the Wisconsin Chippewa jettisoned along the St. Louis River or scrapped to be used as fuel for the frigid nights. Then they set off on foot along the frozen trails eastward, heavily laden with the goods for their families. By the Chippewa's own reckoning, many more died on the trails home than had died at Sandy Lake.[72]

The total mortality for this whole sorry episode cannot be determined exactly. Watrous, himself, although sometimes claiming reports of epidemics and starvation were exaggerated, admitted that more than 150 had died at Sandy Lake proper, including twenty of those left in his charge after the Chippewa departed. About two hundred was the estimate of several missionaries present part of the time at the new Sub-Agency during these events, while William W. Warren, a month after the goods distribution, reported that nearly two hundred died at Sandy Lake alone. But the best enumerations were likely those of the Chippewa leaders themselves, for they were totaling up their own deceased kin. Two separate reports from them, one from the elder Psheke [Buffalo] and his fellow leaders at La Pointe in November, 1851, and a second from the interior Wisconsin leaders a year later, agreed that 170 died during the time spent waiting at Sandy Lake, with another 230 dying on the return trip. Most of these were adults, mainly able-bodied men, an especially hard blow to these small populations. Thus, of the population at risk, something less than three thousand, the Ewing-Brown-Ramsey-Watrous plan to lure the Lake Superior Chippewa west and trap them there successfully removed some twelve per cent, by killing them. The human loss was one thing: in addition the Chippewa also lost much capital equipment (their canoes), much critical subsistence work and other productive economic activity, and they went further into debt, when they were forced to encumber unpaid and future annuity funds for survival rations.[73]

After returning to their homes, the Chippewa were even more determined to avoid removal. Neither would they at any time of the year so much as visit Sandy Lake, which they now defined as a "graveyard." Once information of the winter's carnage became public, Watrous came under sharp, continuing attack from the Chippewa and their now numerous supporters. Missionary groups, regional newspapers, and local citizens led the opposition, and the legislatures of Wisconsin and Minnesota aided, while the Chippewa themselves began organizing a series of memorials and delegations to Governor Ramsey and to Washington. Within six months the new Commissioner of Indian Affairs, Luke Lea, and the Secretary of the Interior responded to this lobbying effort, seemingly in favor of the Chippewa.

On August 25, 1851, the Secretary issued instructions apparently rescinding the 1850 removal order. Transmitted to Watrous by telegraph, this information became immediate public knowledge, spread by the *Lake Superior News* in an account highly favorable to the Chippewa. A few weeks later, leaders from the La Pointe and other bands traveled to Sault Ste Marie for a grand "Indian Jubilee" celebrating their victory. The rejoicing was premature. Although the removal order itself was publicly withdrawn, actual efforts to accomplish this goal were not ended; for the requirement that annuities be paid only to Chippewa in the west remained in force, and Agent Watrous continued determined efforts to dislodge them on an even larger scale than earlier.[74]

Backed by Governor Ramsey, Watrous had begun active, large-scale removal operations early in the year, and these continued through 1851 and 1852 irrespective of publicized instructions from Washington. Recognizing that the Chippewa would have nothing to do with Sandy Lake, Watrous selected Crow Wing and Fond du Lac as destinations more likely acceptable to them. He marshalled his forces, employed more personnel, placed influential marginals such as William W. Warren and missionaries such as W. L. Boutwell on his payroll, stockpiled resources, let contracts, issued assembly orders, called for troops to aid his work (which were refused), and scurried around the region working to lure the Chippewa out of their ceded territory, all the while affecting to keep his plans secret from the Chippewa and their American allies.

The one major incentive Watrous had was the annuity fund, now doubled because of the accumulation of 1850 and 1851 installments. To increase the pressure he refused payment in Wisconsin to any subdivision of the Chippewa: Pagan, Christian, Successful Farmer, New Land Owner, Half-Breed, Lake Shore Fisherman, Interior Hunter, whatever. And in autumn, 1851, he made plain that he still favored the same deception plan and tactics that had proved so disastrous a year earlier. "It is my intention," he reported to Ramsey on September 22, "to delay (unless otherwise instructed) making the moneyed payment of the present year to the Chippewas of Lake Superior until after navigation ceases, which is done to throw every obstacle in the way of their returning to their old homes." The governor did not otherwise instruct.[75]

However, in spite of all the preparations and expenditures, most Chippewa would have nothing to do with these plans. Many traveled to Fond du Lac or Crow Wing that fall; after obtaining their annuities, few tarried to experience a repeat of the previous year's debacle. Nonetheless, the newly promoted Agent Watrous proclaimed near total success, reporting that only seven hundred Chippewa remained in the east subject to later removal. His reports were seconded by

Governor Ramsey, who also professed victory in his Annual Report. Both were dissembling, as local citizens, employees of the removal effort, missionaries, the newspapers, and the Indians themselves well knew. The Wisconsin and Upper Peninsula Chippewa remained within their old band territories, irrespective of the change in their status caused by Wisconsin's statehood and the cession of their lands.[76]

These attempts to dislodge the Lake Superior Chippewa continued through 1852, but with diminishing effect. As the protests of the Chippewa and their allies grew in volume, and evidence of costly failures mounted, a final delegation to Washington at last produced success. Following a meeting of old Psheke from La Pointe with the President in late June, 1852, when another petition from the citizens of the Lake Superior shore was presented, Millard Fillmore finally cancelled the removal authorization entirely. Of even greater value to the Chippewa, the President now approved the payment of back, current, and future annuities at La Pointe. The Chippewa victory was complete two years later. Then, after a Democratic President had taken power in Washington, a new Commissioner of Indian Affairs, George W. Manypenny, dismantled the old Indian removal policy and installed a new program emphasizing concentration on reservations and economic development in place. On September 30, 1854, the Lake Superior Chippewa signed their last treaty with the United States, one severing relationships with the Mississippi bands, and guaranteeing them the right to reside on and take their subsistence from reservations within the environments they had long inhabited.[77]

Forty years ago, in the first attempt to find order in the implementation of the removal policy among the Indians of the Old Northwest, Grant Foreman concluded that their resettlement was, "haphazard, not coordinated, and wholly unsystematized," and further asserted that the whole period for these peoples was characterized by no pattern.[78] But if we plot the different responses of all Old Northwest Indian societies to the removal policy against the basic forms of their adaptations to broad biotic zones, their different types of social organization, and the paths and various goals of American intrusions into their lands, a clear matrix emerges. This underlying pattern yields a near mutually exclusive distribution of those Indian communities that did resettle in the western Indian Territory against those that did not. By placing their activities into a broader social context, this pattern also helps to make understandable the Chippewa's resistance to relocation.

The Chippewa of Michigan's Upper Peninsula and Wisconsin were by no means alone in their successful resistance to this American inspired and commanded resettlement program. Despite repeated efforts running over many years, the federal authorities entirely failed in efforts to dislodge any of the native societies in the Great Lakes region similar to these Chippewa in basic social organization, technology, subsistence economy, environmental adaptation, and culture.

Those Old Northwest Indians whose assessments of the removal policy were most strongly negative were foraging peoples, dependent on hunting, fishing, and gathering for their subsistence, while they exchanged for manufactured goods and money the same products needed for their own sustenance. They inhabited biotic zones characterized by numerous streams, marshes, and lakes, with long, harsh winters and extensive deciduous and coniferous forests. They were also skilled builders and users of framed-up bark canoes, their main means of transportation. And their direct contacts and

experience with the western prairie lands were few or none.[79]

Thus, the Lake Superior Chippewa's success in thwarting implementation of the removal policy was true also of extensive populations of other Chippewa communities, and the Menomini, Ottawa, and those Potawatomi villages on the Lake Michigan shore above present Milwaukee. Organized as small, autonomous bands, these native peoples had maintained their political, social, cultural, and religious integrity to a degree well beyond those of Ohio, Indiana, and Illinois. Moreover, throughout the era these Old Northwest Indians were not surrounded by Americans, agriculturalists or otherwise. Hence they and Americans were not immediately in open competition for the resources of the same environments. These foraging bands, confidently following their own cultural and adaptational trajectories, recognized no advantage in westward migration away from habitats familiar to them. Instead, they defined this possibility as greatly damaging to their welfare. Indeed, several thousand Indians from these communities, when faced with the prospect of closer dealings with Americans and their authorities, did voluntarily abandon their lands in the United States. But these slipped across the international border into Canada and resettled in locations similar in climate, flora, and fauna to those they had abandoned.[80]

To the south an entirely different pattern of Indian responses to the removal policy emerged. In striking contrast to the reactions of the foraging bands in the northern reaches of the Old Northwest, when the era closed all the Indians there—with some few exceptions—had been dislocated and resettled in the west. These were multi-community tribal societies such as the Shawnee, Delaware, Wyandot, Kickapoo, and Sauk. They occupied habitats characterized by relatively long growing seasons, prairie and parklands, fertile bottom lands, and hardwood forests. They lived in large, semi-permanent villages, and their traditional economies had been based on a mix of intensive horticulture and large-game hunting.[81]

Moreover, well before the removal era began in 1825 they had been forced to adapt to a new environmental reality: large numbers of American farmers, merchants, entrepreneurs, and developers were a significant and threatening part of their milieu. Occupying the ground directly in the path of the post-Revolutionary frontier, for decades their relations with these newcomers had been marked by intense, open rivalries, for they were involved in sometimes violent competition for the same environmental resources. Thus they had long been involved in land cessions. Some, like the Mdewakanton in 1837, had more or less eagerly exchanged less critical portions of their estates for goods, immediate cash payments, and annuities. Others had been driven to such sales by intense pressures from appointed negotiators and other interested parties. Understandably, the effects of the removal policy fell on them earlier and heavier than on the northern foragers like the Chippewa. Indeed, the first treaties with any Indians— either of the Old Northwest or the Southeast—to be impelled by and obtained under the specific terms of the 1830 Removal Act were negotiated with several such communities in Ohio.[82]

These farming, large-game hunting tribal societies of the Old Northwest's prairie lands were also distinct from the foraging bands to the north in another salient characteristic. While the foragers remained committed to bark canoe transport, those to the south had long since abandoned such frail vessels in favor of horses. Indeed, twenty years before Thomas Jefferson conceived of using the newly acquired Louisiana Territory as a suitably distand homeland for Indians,

numerous Shawnee, and Delaware, followed by lesser numbers of Kickapoo, Illini, and Potawatomi, had used their new means of travel voluntarily to abandon their land in the Old Northwest and resettle in Missouri and Arkansas, with some going as far west as Texas.[83] Since horses facilitated East-West movement of people and goods across the valleys of the great midcontinent river systems, even those who stayed in the remains of their old tribal estates were enabled to add seasonal horse-nomadism for purposes of hunting, trade, diplomacy, and war to their technological inventory. Oriented to large game hunting from the start, when they faced increased competition with Americans near their lands, they used horses to bring the resources of the western environments within their reach.

Hence, by 1825 not only were many from these prairie tribes familiar with the western environments, but several related pioneer Indian communities were already well established there. Indeed, through the 1830s, emissaries from such western trail breakers often visited their kin in Ohio, Illinois, and Indiana, soliciting new recruits and allies.[84] The Lake Superior Chippewa, and other bark canoe-using foragers of the north, had no such experiences, technological capacity, relationships, or inclinations.

There were some few exceptions to this general dislocation and westward resettlement of the prairie tribes. These included some hundreds of Indiana Miami and fewer Michigan Potawatomi who were allowed, by negotiated treaty right, to remain on small parcels in their old environments.[85] Then there were the many who escaped the full consequences of American policy by resettling in British territory. These included numerous horse-nomadic Potawatomi, Ohio Ottawa, and others who settled on the Ontario Peninsula. Making appropriate ecological choices, these voluntary emigrants selected locations south of the Canadian Shield region, in habitats and a climate like those familiar to them. These immigrants studiously avoided British efforts to concentrate on the—to them—barren landscape of Manitoulin Island, further demonstrating the significance of both environmental adaptations and the capacity of Old Northwest Indians to bend the policies of powerful states to their own wants and ends.[86]

More recently than Foreman, Prucha, stressing the extensive prior moves of the Old Northwest's native peoples, concluded that "the emigration of these tribes in the Jacksonian era was part of their migration history.[87] Such an interpretation places the most charitable interpretation conceivable on this American policy, but it does not distinguish one type of migration from another; neither does it look far beneath the surface appearances of events. Such an interpretation is rather like concluding that the experience of Japanese-Americans between 1942 and 1946 may be adequately explained as part of their prior migration history as well.

In a larger historical perspective, none of the Great Lakes-Ohio Valley Indian societies had ever experienced a program quite like the American removal policy as arranged and conducted in the years after 1825. Some, such as the Ontario Iroquoian and Michigan's Algonquian horticultural tribes, during the second half of the seventeenth century had been refugees, fleeing the ravages of war, pestilence, and starvation. Many had sometimes responded to the incentives offered by French or British traders and officials in selecting sites for new settlements. For more, including the Chippewa, their earlier migrations were in response to internal stresses such as population increase, intra-community conflict, resource depletion, or a particularly successful adaptation to new technologies and economic opportunities. Such relocations were

generally voluntary, even if encouraged by inducements from European colonial officials, not forced. None of the Indian communities in this region had, until the mid-1820s, collided with a rapidly expanding nation-state bent on fueling its own internal development by the wholesale expropriation of resources and dispossession and dislocation of native inhabitants. The fact that in some instances the goals of particular Old Northwest Indian communities converged with the policies of the United States does not distract from this conclusion. It demonstrates merely that these Indians were adaptable enough to hunt out new opportunities in an unmapped thicket of adversity.

"Settlement pressure" is the most popular, widespread and persistent explanation of the timing or the sequence of efforts at implementing the removal policy.[88] However, as a single-factor explanation this will do neither for the examples of the Chippewa and neighboring foraging bands nor for Old Northwest Indians generally. For at the moment the four American officials conceived their plan to deceive and dislodge the Lake Superior Chippewa, there were few or no Americans "pressing" on their lands. Nor were there many for decades thereafter. Indeed, as witnessed, these Indians found many staunch supporters among the small populations of neighboring citizens. Similarly, had the density of neighboring American population been the major cause of removals, then the perennially reluctant Wyandot of northwest Ohio would have been forcibly transported west at least a decade before their 1843 capitulation and resettlement. "Settlement pressure," perhaps phrased better as significant competition between Americans and Indians for the latter's environmental resources, helps explain how and when Indians were pressured to cede land. By itself it does not explain the drive to move them to distant locations.

Recognizing this distinction—between the acquisition of Indian land and their planned resettlement in distant places—also requires distinguishing the manifest from the less well-recognized functions of the removal policy after 1825. Doing so helps us better understand not only this extraordinary Chippewa case, but efforts to implement this policy among other Old Northwest Indians generally. For decades before 1825, the overt business of acquiring Indian rights to occupy and use the resources of land had been commonly accomplished without necessarily demanding or forcing resettlement in remote locations, certainly not so to an area officially demarked as an exclusive "Indian Territory." Frequently, this was achieved by acquisition of most or nearly all of an Indian society's land, leaving them to concentrate on the remaining parcels of their old estates. Indeed, this was the explicit intention spelled out in the Chippewa's 1837 treaty, not the requirement that they resettle in the west. Moreover, when this planned resettlement policy was finally succeeded by its replacement (the reservation policy), substantial populations of near or entirely landless Indians remained in Michigan and Wisconsin, with smaller groups in Ohio and Indiana, as well as throughout the eastern United States. This did not cause an appreciable slowing of the populating or economic development of these regions. Before and after the years when a comprehensive, nationwide removal policy was in effect, indeed, even between 1825 and the early 1850s, Americans pressing on Indian environments acquired titles to and control of most Indian land without demanding resettlement in a designated all-Indian Territory.

The Chippewa's experiences between 1842 and 1852 forces our attention to a

different issue, the understory of the drive to relocate Indians in the west, and to additional conclusions. Whatever the much idealized rationalizations of the Jefferson, Monroe, Adams, and Jackson administrations about the goals of Indian removal, well before 1842—and especially so before the disastrous winter of 1850–1851—the transportation and resettlement of eastern Indians under the ideological guise of benevolent public policy had acquired an institutional life of its own. In the business of collecting, uprooting, transporting, and subsisting Indians, numerous public officials and private citizens discovered incentives and rewards. Removing Indians was often made to serve neither the declared wants, the assessed needs or the passions of neighboring citizens, nor the long range values of a nation. It served, rather, the imperatives of the American state and specifically the narrow political-economic patronage concerns of whatever administration was in power.

In the instance of the abortive effort to dislodge and to resettle the Lake Superior Chippewa, we witness a national patronage system gone awry. Secretary of the Interior Ewing, Commissioner of Indian Affairs Brown, Territorial Governor Ramsey, and the unusually eager and ambitious Sub-Agent Watrous, each from his own distinctive concerns, each with his own network of patrons and henchmen to serve or to satisfy, were directly responsible for arranging this affair. Each bent a near obsolete public policy to his personal career interests and political obligations.[89] Certainly, the consequences of their decisions were exacerbated by legislative chance and environmental accident. Nonetheless the Chippewa's death march was directly caused, to borrow James MacGregor Burns' illuminating phrase, by the self-interested operations of several of those "little circles of influence" that have plagued American life for two centuries.[90] Sub-Agent Watrous did not have to cause the actual permanent relocation of the Chippewa to achieve his personal or his political goals; he had only to seem to do so. Being able to claim a large increase in the Indians under his jurisdiction, he was successful in obtaining an upgrading of the status of his post to a full agency, a promotion to agent, the doubling of his salary, and whatever gratuities grateful St. Paul contractors and Sandy Lake traders may have delivered into his hands.

But what did these Chippewa accomplish for themselves by effectively blocking the efforts of American officials to treat them as an exploitable natural resource? The late Homer G. Barnett has noted that "Dispossession of land and its equivalent, migration, requires adaptation if a group is to survive."[91] The Lake Superior Chippewa, by the terms of the treaties of 1837 and 1842, experienced the loss of ownership of the habitats they had conquered a century earlier, although they skillfully avoided total eviction from these lands. Nonetheless, although they escaped forced emigration, they, too, had to adapt, for their social and physical environments did not remain constant. For decades they were able to apply old knowledge and skills to obtain the essentials for their lives, ranging over familiar terrain, still little settled by Americans, exploiting known sources of food and raw material, while also adjusting themselves to the changing circumstances brought by booming timber and mining industries, and by their status as dependent wards of the federal government.

It was twenty years before all the reservations granted in the 1854 treaty were selected and surveyed, at which moment American settlements had advanced to the point where the federal government at last required the Wisconsin Chippewa to settle

on and to extract their subsistence from within these confined spaces. It was in the mid-1870s that the first clear evidence of cultural disintegration appeared in the form of a revitalization movement, the Dream Dance, a missionary-spread new religion, which sought through collective application of supernatural power to defeat American economic and political ascendancy. A full century later, the legal heirs and political successors to the old Chippewa bands turned to the federal courts for a different type of aid, seeking to recover rights allegedly granted to their ancestors by treaty. Employing quite different premises and tactics than in earlier years, the modern Chippewa have met with somewhat greater success. By the later 1980s, they were truly experiencing intensive "settlement pressure," that is, competition for scarce natural resources with their neighbors. The consequences of this latest engagement between Chippewa, American neighbor, and the federal patronage system will be a task for some future scholar to describe, assess, and explain.[92]

Endnotes

[1] This essay reports some findings of the Old Northwest Indian Removal Project, which was supported by a research grant from the National Endowment of the Humanities. The author is indebted to numerous readers of earlier drafts for their aid and useful suggestions, especially Victor Barnouw, Tom Biolsi, John Clark, Faye Clifton, Conrad Heidenreich, Michael Green, Jeanne Kay, Robert Kvasnicka, James McClurken, Joseph Manzo, Bruce Trigger and Richard White; and also Paul Haas, John D. Haeger, and Paul Prucha. In the interests of saving space, citations for this essay have been much abbreviated. A full bibliography is contained in the author's *The Voight Decision and Wisconsin Chippewa Treaty Rights: A Critical Bibliography* (Institute for the Development of Indian Law, forthcoming); and in the archives of the Old Northwest Indian Removal Project.

[2] The nomenclature, "Lake Superior Chippewa," came into use only during negotiations for the Treaty of 1854 at the insistence of the Wisconsin and Upper Peninsula of Michigan bands, who wished to sever all relationships with the bands on the Upper Mississippi River. See, R. Ritzenthaler, "Southwestern Chippewa," in B. G. Trigger, ed., *Handbook of North American Indians,* Vol. 15, *Northeast* (Smithsonian Institution, 1978), 743-59.

[3] The incident is mentioned in a few older state and regional histories such as J. N. Davidson's, *In Unnamed Wisconsin* (Milwaukee 1895), 168; and is briefly discussed in V. Barnouw's *Acculturation and Personality Among the Wisconsin Chippewa* (American Anthropological Association Memoir No. 72, 1950), 37, 59. Such descriptions are based on other secondary and scanty primary sources, principally the Rev. J. H. Pitezel's eyewitness account in *Lights and Shades of Missionary Life* (Cincinnati, 1860), 298. E. J. Danziger, in his *The Chippewas of Lake Superior* (University of Oklahoma Press, 1978), 88, and his "They Would Not be Moved: The Chippewa Treaty of 1854," *Minnesota History,* 43 (1973), 178, touches the episode in passing. William C. Haygood's editorial comments, accompanying publication of excerpts from Benjamin J. Armstrong's reminiscences in his old age, attempted a sketchy assessment of the incident, but these remarks are not well informed. See, "Reminiscences of Life Among the Chippewa," *Wisconsin Magazine of History,* 4 Parts, 55: 175-96, 287-309; & 56: 37-58, 140-61. In the extensive interviewing preceding his *Wisconsin Chippewa Myths and Tales and Their Relation to Chippewa Life* (University of Wisconsin Press, 1977), Barnouw found no oral traditions concerning the events (Barnouw to Clifton, Personal Communication, 1985). Nor are there any such folk memories recorded in the major 20th-Century collections of Chippewa oral traditions, such as the Charles Brown Papers, Col. HB, State Historical Society of Wisconsin, or the U. S. Works Progress Administration's Chippewa Historical Project Records, Microfilm 532, State Historical Society of Wisconsin. The last recorded Chippewa mention of this episode dates to 1864, when the Lake Superior chiefs assembled to record their memories of treaty dealings with the United States. See, G. P. Warren, "Statement of Treaties between the Chippewa Indians and the United States, from 1825-1864, from the Chippewa Standpoint," File 1864, Guide 714 (State Historical Society of Wisconsin).

[4] The cases include, in Wisconsin—the Win-

nebago, Menomini, Potawatomi communities north of Milwaukee, Chippewa of Lake Superior, Mdewakonton Dakota, and the Emigrant New York Indians (Oneida, Stockbridge-Munsee, and the Brotherton); in Ohio—five groups; in Indiana—two groups; in Illinois—three groups; in Michigan—six groups; and from Ontario—two small groups, the Moravian Delaware and Anderdon Hurons.

[5] For the Indiana Potawatomi episode, see J. A. Clifton, *The Prairie People: Continuity and Change in Potawatomi Indian Culture* (Lawrence: Regents Press of Kansas, 1977), 270–72, 296–99; and, R. A. Trennert, Jr., "A Trader's Role in the Potawatomi Removal from Indiana: The Case of George W. Ewing," *The Old Northwest,* 4 (1978), 3–24. The best overview of the Winnebago case is N. O. Lurie, "Winnebago," in, Trigger, *Handbook . . . Northeast,* 690–707. For the Sauk and Fox case see A. F. C. Wallace "Prelude to Disaster," which is lodged amidst Ellen M. Whitney's near comprehensive collection of documents bearing on that episode, *Collections of the Illinois State Historical Library,* 35 (1970).

[6] Recent historical studies of Indian removal exhibit a striking bias as regards commercial "motives" in Indian removal. In his overview of Old Northwest removal, for instance, F. P. Prucha devotes a full section to this topic without once mentioning the involvement and interests of Protestant and Catholic missionaries in implementation of the policy in the region. See his, *The Great Father: The United States Government and the American Indians* (University of Nebraska Press, 1984), Vol. 1, 266–69. Compare, G. A. Schultz, *An Indian Canaan: Isaac McCoy and the Vision of an Indian State* (University of Oklahoma Press, 1972), 123–40.

[7] L. Taliaferro Journals (Minnesota Historical Society), Vol. 10, May 22, 1836; R. W. Meyer, *History of the Santee Sioux* (University of Nebraska Press, 1967), 56–59; H. Hickerson, *Sioux Indians I: Mdewakanton Band of Sioux Indians* (New York: Garland, 1974), 159–205.

[8] *Kinsmen of Another Kind: Dakota-White Relations in the Upper Mississippi Valley, 1650–1862* (University of Nebraska Press, 1984), esp. x–xiii and 150–57.

[9] For background to the Moravian migration, see F. C. Hamil, *The Valley of the Lower Thames, 1640–1850* (University of Toronto Press, 1951), 108–111; C. A. Weslager, *The Delaware Indians: A History* (Rutgers University Press, 1972); and, I. Goddard, "Delaware," in Trigger, *Handbook . . . Northeast,* 213–239. For the background on the Anderdon Hurons, see, C. E. Heidenreich, "Huron," and E. Tooker, "Wyandot," in Trigger, *Handbook . . . Northeast,* 369–88 and 398–406; J. A. Clifton, "Hurons of the West: Migrations and Adaptations of the Ontario Iroquoians, 1650–1704," Research Report, Canadian Ethnology Service, National Museum of Man (Ottawa, 1977); and his, "The Re-emergent Wyandot: A Study in Ethnogenesis on the Detroit River Borderland, 1747," in, K. G. Pryke and L. L. Kulisek, eds., *The Western District* (University of Windsor, 1983); C. G. Klopfenstein, "The Removal of the Wyandots from Ohio," *Ohio Histroical Quarterly,* 66 (1957), 119–136; Robert E. Smith, Jr., "The Clash of Leadership at the Grand Reserve: The Wyandot Sub-Agency and the Methodist Mission, 1820–1824," *Ohio History,* 89 (1980), 181–205; and, E. J. Lajeunesse, C.S.B., *The Windsor Border Region* (Toronto: The Champlain Society, 1960).

[10] M. J. Mochon, "Stockbridge-Munsee Cultural Adaptations: 'Assimilated Indians.' " *Proceedings of the American Philosophical Society* 112 (1968), 182–219.

[11] Rev. J. Vogler to H. R. Schoolcraft, April 10; Schoolcraft to Commissioner of Indian Affairs [COIA] C. A. Harris, April 17 & 28; COIA to Schoolcraft, April 29; Schoolcraft to Vogler, May 8, 1837, in, *Records of the Michigan Superintendency, National Archives Microfilm Series M1* [NAM M[1]], Rolls 37 & 42. Schoolcraft to COIA August 14, and to Gov. H. Dodge, 14 August, 1837, *NAM M1,* Roll 37. Supt. W. Clark to COIA, November 17, 1837, *Office of Indian Affairs, Letters Received, NAM M234,* Roll 756; Harris to Captain E. A. Hitchcock, December 2, 1837, *Office of Indian Affairs, Letters Sent, NAM M21,* Roll 23. R. Cummins to Pilcher, February 4, 1840, *NAM M234,* Roll 301. J. Johnston to COIA T. H. Crawford, March 14, 1842, *NAM M234,* Roll 602; Wyandots of Canada to Sir Charles Bagot, October 10, 1842, *Record Group 10:, Indian Affairs, Red Series—Eastern Canada* (Ottawa, Public Archives of Canada) [*PAC RG10*], Vol. 125. For the joint emigration, See Klopfenstein, "Removal of the Wyandots." Petition of the Hurons to Col. William Jarvis, May 3, 1842, *PAC RG10,* Vol. 125. Wyandot Muster Roll —1843, Entry 301, *Record Group 75, Records*

of the Bureau of Indian Affairs, National Archives and Records Service [RG75].

[12] J. A. Clifton, *A Place of Refuge For All Time: Migration of the American Potawatomi Into Upper Canada* (Ottawa: National Museum of Man, 1975); R. F. Bauman, "The Migration of the Ottawa Indians from the Maumee Valley to Walpole Island," *Northwest Ohio Quarterly,* 21 (1949), 86–112.

[13] Gov. Ramsey's report, November 3, 1851, in *Annual Report of the Commissioner of Indian Affairs* (Washington, D.C., 1851) [ARCOIA], 421–22. For sketches of the use of force and of those communities which avoided removal, see the relevant chapters in Trigger, *Handbook . . . Northeast:* see also, Mochon, "Stockbridge-Munsee"; Clifton, *Prairie People* and *The Pokagons, 1683–1983: Catholic Potawatomi of the St. Joseph River Valley* (University Press of America, 1984), Wallace, *Prelude to Disaster;* and, P. K. Ourada, *The Menominee Indians: A History* (University of Oklahoma Press, 1979), 106–123.

[14] H. R. Schoolcraft, *Personal Memoirs of a Residence of Thirty Years with the Indian Tribes on the American Frontiers* (Philadelphia, 1851), 628–29; A. Jackson's Message of March 4, 1837, in, J. D. Richardson, comp., *A Compilation of the Messages and Papers of the Presidents, 1789–1897* (Washington, D.C., 1896–1899), Vol. 2, 541; M. Van Buren's Message of December 5, 1837, in, F. L. Israel, ed., *The State of the Union Messages of the Presidents* (New York, 1966), Vol. 1, 490; *ARCOIA* (1838), 410–411.

[15] Prucha's *The Great Father,* 241–42, provides a useful recent overview of selected features of Old Northwest Removal. The author views the whole process through the eyes of American elites and authorities in Washington, often reflecting but not penetrating their idealized aims and ideological pronouncements, while displaying little understanding of the native peoples and their responses to the policy.

[16] W. Miles, " 'Enamoured with Colonization': Isaac McCoy's Plan of Indian Reform," *The Kansas Historical Quarterly,* 38 (1972), 268–286, has done so.

[17] Treaty with the Sioux, etc., August 19, 1825, 7 U.S. Statutes 272; Treaty with the Chippewa, August 5, 1826, 7 U.S. Statutes 290; and, Treaty with the Chippewa, etc., August 11, 1827, 7 U.S. Statutes 303. Also, Charles J. Kappler, comp. *Indian Treaties: 1778–1883* (reprinted, New York, 1972), 250–55, 268–71; 281–83.

[18] Kappler, *Indian Treaties,* 269.

[19] Flat Mouth's speech, in, Taliaferro to Governor Henry Dodge, September 29, 1836. *NAM M234,* Roll 757. He was referring to the 1836 treaty with the Ottawa and Chippewa of Michigan. For accounts of Lake Superior Chippewa impoverishment in this period, see, G. Franchere to W. Brewster, 14 March 1835, Records of the American Fur Company, Steere Collection, Baylis Public Library, Sault Ste Marie, Michigan, Box 1, Folder 3; Bisheke [Chief Buffalo] to H. R. Schoolcraft, September 8, 1835, *NAM M1,* Roll 72; and, E. A. Brush to Lewis Cass, *NAM M234,* Roll 664.

[20] Secretary of War Lewis Cass to President Van Buren, March 7, 1836, *NAM M21, Roll 18.*

[21] The correspondence, reports, petitions, and memorials concerning their efforts are extensive. For samples, see, S. C. Stambaugh to H. R. Schoolcraft, June 8, 1836, *NAM M1,* Roll 72; COIA C. A. Harris to Governor Dodge, October 15, 1836, *NAM M21,* Roll 20; and, Bailey to COIA E. Herring, June 18, 1836, *NAM M234,* Roll 422.

[22] COIA Harris to A. Bailey, July 15, 1836, *NAM M21,* Roll 19; Hitchcock to Harris, March 30, 1837, *NAM M234,* Roll 751; Taliaferro to Dodge, 30 January, 24 July, and August 2, 1837, *NAM M234,* Roll 758; and, Dodge to Harris, August 15, 1837, *NAM M234,* Roll 758. Major Hitchcock, a regular Army officer, was disbursing agent at the St. Louis Indian Superintendency. The antagonism of some Chippewa to certain traders was real. In December, 1836 a party of Chippewa murdered William Aitken, Jr., the son of a prominent trader by an Indian woman, one of the rare acts of violence by these Chippewa against Americans.

[23] Identified as Royce Area 242, Fig. 1.

[24] COIA Harris to Dodge and General William Smith, May 13, 1837, *NAM M21,* Roll 21. General Smith did not arrive to participate in the treaty negotiations. Earlier, when Secretary of War Cass issued orders for removal treaties with the Winnebago, Menomini, and Emigrant New York Indians, he explicitly excluded the interior Wisconsin Chippewa. See, Cass to Dodge, July 7, 1836, *'NAM M21,* Roll 19.

[25] The first sub-agent at La Pointe, Daniel P. Bushnell, was appointed by Governor Dodge in November, 1836, but was not confirmed until the following April. Edward E. Hill, *The Office of Indian Affairs, 1824–1880: Historical Sketches* (New York, 1974), 88.

[26] Edward D. Neill, "Occurences in and

Around Fort Snelling, from 1819 to 1840," *Minnesota Historical Society Collections,* Vol. 2, 131; William T. Boutwell, "Journel," July 5, 1837, in, *Boutwell Papers.* Col. A.B. 781, Minnesota Historical Society; and, "D. P. Bushell's Report," in, *ARCOIA,* (1838), 467-68.

[27] 1837 Treaty Journal, encl. in Van Antwerp to COIA, September 30, 1837, *Documents Relating to the Negotiation of Ratified and Unratified Treaties, with Various Indian Tribes, 1801-1869, NAM T494,* Roll 3; Warren, "Statement of Treaties." Also see, Hill, *The Office of Indian Affairs,* 90-91, 160-61.

[28] Both came from villages outside the area being ceded. *Magegabow* was a war chief from Leech Lake, *Bugonageshig* an extraordinarily ambitious upstart village leader from Gull Lake. See, James G. E. Smith, *Leadership Among the Southwestern Ojibwa,* Publications in Ethnology No. 7, National Museum of Man (Ottawa, 1973).

[29] See Dodge's marginal notes on p. 21 of the treaty journal to this effect.

[30] This they subsequently did. See, Warren, "Statement of Treaties"; and, Obishkawzaugee's Speech, September 12, 1869, *NAM M234,* Roll 394.

[31] Boutwell to Rev. David Green, August 17, 1837, *American Board of Commissioners for Foreign Missions Papers* (Minnesota Historical Society—Transcripts of Originals in Houghton Library, Harvard University) [ABCFMPMNHS], Box 2.

[32] Rev. Frederick Ayer to President Martin Van Buren, September 30, 1837; Gov. Dodge to COIA, February 17, 1838, *NAM M234,* Roll 387.

[33] J. Schoolcraft to H. R. Schoolcraft, November 21 and December 1, 1837, *NAM M1,* Roll 45.

[34] B. F. Baker to COIA, January 9, 1838, *NAM M234,* Roll 758; Dodge to COIA, July 6, 1838, in, C. F. Carter and J. P. Bloom, eds., *Territorial Papers of the United States* (Washington, D.C., 1934-1969) [TPUS], Vol. 17, 1029-31; and, COIA to Dodge, July 26, 1838, *NAM M21,* Roll 24; A. Brunson to R. Stuart, July 20, 1843, *NAM M1,* Roll 55.

[35] A. W. Schorger, "The White-Tailed Deer in Early Wisconsin," *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters,* 42 (1953), 197-247; and, H. Hickerson, *The Southwestern Chippewa: An Ethnohistorical Study,* American Anthropological Association Memoir No. 92 (1962), 12-27. Gary C. Anderson in, *Little Crow: Spokesman for the Sioux* (Minnesota Historical Society Press, 1986), p. 57, points out that by 1851 Medwakanton Dakota were again hunting deer in the St. Croix valley, then "more abundant than in previous seasons," near areas cut-over by timber men.

[36] D. P. Bushnell to Dodge, February 12, 1839, *TPUS* 27:1196; and, H. Dodge to Secretary of War, April 25, 1841, *NAM M234,* Roll 759.

[37] Treaty with the Chippewa, October 4, 1842, 7 U. S. Statutes 591; Kappler, *Indian Treaties,* 542-45. The lands involved are identified as Royce Area 261, Fig. 1.

[38] For a discussion of "half-breeds," "mixed-bloods," and other cultural marginals, see, James A. Clifton, *Being and Becoming Indian: Biographic Studies of North American Frontiers* (Chicago, The Dorsey Press, in press).

[39] Kappler, *Indian Treaties,* 542-45. Official Documentation for this treaty is scanty, since Stuart kept no journal and delivered no written report on his deliberations. However, the Rev. L. H. Wheeler independently prepared a journal, including a particularly full eye-witness description of events, which he sent to his superior, David Greene, May 3, 1843, ABCFMP-MNHS, Box 3. Moreover, because of the controversy aroused, there is an unusual amount of supplementary reporting on these negotiations, for example in Warren, "Statement of Treaties," and from other Chippewa and American participants, such as A. Brunson to J. D. Doty, January 6, 1843, NAM M1, Roll 54.

[40] P. Holland, *The Philosophie, Commonlie Called, The Morals of Plutarchus* (London, 1603), 1237.

[41] COIA Crawford to Stuart, August 1, 1842, *NAM M1,* Roll 53.

[42] A. Brunson, *A Western Pioneer* (Cincinnati, 1872), Vol. 2, 165-69; Stuart to COIA, October 24 and November 19, 1842, *NAM M1,* Roll 39; *ARCOIA* 1842, 401-402; A. Brunson to Gov. J. D. Doty, January 8, 1843 (encl., letter from Chief Buffalo to L. Warren, October 29, 1842 & speech of White Crow, December 18, 1842), *NAM M234,* Roll 388; and the Rev. Wheeler's account of the negotiations, cited above.

[43] Stuart, "Substance of Talk to the Chippewa," September 29, 1842 (a communication reconstructed later and enclosed in Stuart to COIA, March 29, 1844), *NAM M234,* Roll 389. Cyrus Mendenhall to COIA, January 6, 1851; Rev. L. H. Wheeler, "Journal of 1842 Treaty," in, Wheeler to Rev. David Greene, May 3, 1843, ABCFMP-MNHS, Box 3; Stuart

to Rev. Greene, December 8, 1842; Chief Martin to Rev. A. Brunson, encl. in Brunson to COIA, to Gov. Doty, and to Secy. War Spencer, January 8, 1843, *NAM M234,* Roll 388; Warren, "Statement of Treaties" (section on 1842 treaty).

[44] In the memoir dictated in his old age, B. G. Armstrong claimed Stuart had promised that the Chippewa could remain on their lands so long as they remained peaceful. There is no independent suggestion of the truth of this assertion—that continued occupancy and use rights were contingent on good behavior as there is little support for other such claims in Armstrong's reminiscences. Americans in the era would have classified any such misbehavior as "depredations," individual acts, which under the Trade and Intercourse Act of 1834 and Chippewa treaties required the punishment of the individuals concerned, not the tribe collectively. Armstrong, a self proclaimed "friend of the Chippewa," was actually an inconsequential figure on this frontier, who in his later years much inflated his role as mover and shaker among the Chippewa and in the corridors of power. He is barely mentioned in contemporary public and private sources, where some of his depictions are contradicted and others unsupported by various eye-witness participants. The original is, *Early Life Among the Indians* (Ashland, Wisconsin, 1892); edited excerpts republished as Armstrong, *Reminiscences.*

[45] Kappler, *Indian Treaties,* 542–45; Brunson to Doty, July 19, 1842, *NAM M234,* Roll 388; Stuart to D. Greene, December 8, 1842, *ABCFMP-MNHS,* Box. 3. For background on mining developments in the area, see R. J. Hybels, "The Lake Superior Copper Fever," *Michigan History,* 23 (1950), 97–119 & 309–26.

[46] Doty to Secretary of War, November 17, 1841; H. L. Dousman and H. H. Sibley to Secretary of War, February 18, 1841; and L. Warren to Doty, October 2, 1841; in, *NAM M234,* Roll 388.

[47] Identified as Royce Area 332, Fig. 1.

[48] Doty to COIA, April 5, 1843, *NAM M234,* Roll 517; and, Stuart to COIA, June 2, 1843, *NAM M1,* Roll 39.

[49] Doty to COIA, April 5, 1843, *NAM M234* Roll 427. COIA to Stuart, 13 May, 1843, *NAM M1* Roll 54. Stuart to COIA, 2 June, 1843 & 29 March, 1844, *NAM M1* Roll 39. COIA W. Medill to I. A. Verplanck & Charles Mix, June 4, 1847, *NAM M21* Roll 39. COIA to Gov. Dodge, August 2 and 16, 1847, *NAM M21* Roll 40. C. Borup to W. A. Richmond, August 31, 1847, *NAM M1* Roll 61. COIA to G. Copway, December 14, 1847, *NAM M21* Roll 40; and, *ARCOIA* 1847, 8–9.

[50] COIA Medill to Dodge, October 31, 1846; and to Henry M. Rice, October 31, 1846, *NAM M21* Roll 38. Medill to Dodge, August 2, 1847; and to Brig. Gen. R. Jones, December 6, 1847, *NAM M21* Roll 40.

[51] There is no hint of such a commitment in the records of this treaty negotiation or in the Chippewa complaints about these immediately thereafter. The 1848 assertion was probably an example of Chippewa negotiating style, although they certainly wanted reservations.

[52] They were imitating the Indians of Michigan's lower peninsula who had used this same tactic successfully more than a decade earlier. See, J. McClurken, "Strangers in Their Own Land," *The Grand River Valley Review* (1985), Vol. 6, 2–26; and J. A. Clifton, "Leopold Pokagon: Transformative Leadership on the St. Joseph River Frontier," *Michigan History* (1985), Vol. 69, 16–23.

[53] Medill to R. McClelland, March 3, 1848, *NAM M21* Roll 40; G. Johnston to H. R. Schoolcraft, June 28 & August 18, 1848, *NAM M234* Roll 771; Medill to J. E. Fletcher, c/o T. Harvey, August 17, 1848, *NAM M21* Roll 41; Petition of Lake Superior Chippewa Head Chiefs, February 5, 1849, House Misc. Doc. 36, 30–2 [CS 544]; Delegation of Chippewa Head Chiefs to President, February 5, 1849, *NAM M234* Roll 390; Medill to Livermore, August 22, 1848 & February 12, 1849, *NAM M21* Roll 41. S. Hall to A. Hall, March 28, 1849, *Northwest Mission Papers* [*NWMP-UMD*] Box 1, Folder 1, University of Minnesota—Duluth; Pitezel Journal, July 9, 1849, *J. H. Pitezel Papers* [*JPP-CHL*], Clarke Historical Library, Central Michigan University. "Chippewas of L'ance," *Lake Superior News & Mining Journal* [*LSN&MJ*], June 12, 1850.

[54] "Removal of the Payments to Sandy Lake," Journal V, 1851, *JPP-CHL.*

[55] R. A. Trennert, "Orlando Brown," in, R. M. Kvasnicka and H. J. Viola, eds., *The Commissioners of Indian Affairs, 1824–1977* (University of Nebraska Press, 1979), 41–48.

[56] Relocating the Chippewa would have meant the loss of the only females then available to loggers and miners. Indeed, the infrequent conflicts that erupted between Americans and Chippewa were occasioned by the former trying to gain sexual access to Chippewa women. See, R. N. Current, *The*

History of Wisconsin: Civil War Era, 1848–1873, (State Historical Society of Wisconsin, 1976), Vol. 2, 154.

[57] H. M. White, *Guide to the Microfilm Edition of the Alexander Ramsey Papers and Records* (Minnesota Historical Society), 16–18; and, Current, *History of Wisconsin,* Vol. 2, 197–205. The Lake Superior Chippewa's annual monetary value that year consisted of $22,000, and $44,200 in goods and services, plus the salaries of employees of the Indian Department. All cash payable in specie—gold and silver. This was a considerable resource for a struggling, cash-poor new Territory. See "Omnibus Appropriation Bill," House Miscellaneous Document 57, November 12, 1850, 31-1, Vol. 2, p. 61 [CS 582].

[58] Presidential Order, February 6, 1850, in C. J. Kappler, *Indian Affairs: Laws and Treaties,* 5 Vols. (Washington, D.C., 1904–1941), Vol. 5: 663; Brown to Ramsey, February 6, 1850, *NAM M21* Roll 43; Ramsey to Livermore, March 4; and, Livermore to Ramsey, March 21, 1850 *NAM M234* Roll 428; Secretary of State, *Legislative Manual of the State of Wisconsin,* 9th Ed. (Madison, 1870), p. 209.

[59] Brown to Watrous, April 22, 1850, *NAM M21* Roll 43; "John S. Watrous File," in, Minnesota Territory, Appointments Division, Secretary's Files, *National Archives Record Group 48, Interior Department Appointment Papers* [*RG48*].

[60] Rev. Wheeler to Ely, June 19 & July 22, 1850; Rev. Hall to Ely, July 16, 1850; in, *E. F. Ely Papers* [*EFEJ-SHSW*], State Historical Society of Wisconsin, Vol. 3.

[61] S. B. Treat to COIA Lea, May 12, 1852, *ABCFMP-MNHS,* Box 6.

[62] J. N. Davidson, "Missions on Chequamegon Bay," *Collections of the Wisconsin State Historical Society,* Vol. 12, 434–52; *Milwaukee Weekly Wisconsin,* June 5, 1850; J. P. Durban to Secretary of the Interior, October 3, 1850, *NAM M234,* Roll 767; D. King, *et al.,* to D. Atkins, July 15, 1850, *NAM M234,* Roll 771; S. Hall to Treat, 28 March 1850, *ABCFMP-MNHS,* Box 5; Hall to Ramsey, 28 March 1850, *NAM M234,* Roll 168; H. Hall to L. D. Mudgett, March 13, 1850, *NWMP-UMD,* Box 1. Hall to Treat, October 7, 1852 and May 17, 1853, *ABCFMP-MNHS,* Box 6.

[63] Mendenhall to Lea, January 6, 1851, *NAM M234* Roll 767; Congressman J. R. Giddings to President, July 30, 1850, w/ encl., Petition from Citizens of Lake Superior South Shore, *NAM M234* Roll 390; *LSN&MJ,* June 5 and 12, 1850; *Milwaukee Weekly Wisconsin,* June 5 and July 3, 1850; J. P. Durban to Secretary of the Interior, October 3, 1850, *NAM M234* Roll 767. D. Aitken to Lea, August 26, 1850, *NAM M234* Roll 771. "Important Movement Among the Chippewa," and, "Chippewa Delegation," *Detroit Free Press,* November 28, 1848 and February 19, 1849.

[64] *LSN&MJ,* June 5, 1850; Pitezel Journal, Vol. 5, June 3, 1850, *JHPP-CHL;* L. H. Wheeler to E. F. Ely, July 22, 1850, E. F. Ely Papers [*EFEP-MNHS*], Minnesota Historical Society, Vol. 3; "Correspondence from J. Bowron," *Boston Daily Journal,* September 14, 1850; Watrous to COIA, December 31, 1850, *NAM M234,* Roll 767; Watrous to Ramsey, November 14, 1850. *NAM M234,* Roll 767.

[65] Brown to Ramsey, March 26, 1850; Watrous was handed his commission in Washington a month later—Brown to Watrous, April 22; *NAM M21,* Roll 43; "Indians to be Removed," June 1, and "From the Lake Superior Journal," June 27, 1850, *Detroit Free Press.*

[66] Pitezel, "President Conditions and Prospects of the Missions," Journal, Vol. 5, July, 1850, *JHPP-CHL;* Hall to Ely, February 24, 1851, *EFEP-MNHS,* Vol. 3; Pitezel, *Lights and Shades,* 247; Hall to Ely, February 24, 1850, Vol. 3, *EFEP-SHSW; Annual Report of the Missionary Society of the Methodist Episcopal Church* [*ARMS-MES*], 1850, 70–71.

[67] Pitezel, "Journal," Vol. 5 (1851), *JHPP-CHL;* Armstrong "Reminiscences," 290–92; W. Bartlett, *History, Tradition, and Adventure in the Chippewa Valley* (Chippewa Falls, Wisconsin, 1929), 67–70, 119–120; Watrous to Ramsey, n.d. [c. December 12], 1850. *NAM M234,* Roll 767.

[68] Bartlett. *History, Traditions,* 69; J. E. Fletcher to Superintendent T. H. Harvey, November 14, 1850, *NAM234,* Roll 760; Pitezel, *Lights and Shades, 298–99; Watrous to Ramsey, November 14; n.d.* [c. December 12]; & December 30, 1850; in *NAM M234* Roll 767. Chippewa Annuity Pay Rolls, 1850, Item 186, Annuity Pay Lists. *RG 75.*

[69] Pitezel, Journal, Vol. 5 *JHPP-CHL* (1851); E. D. Neill, "History of the Ojibways," *Collections of the Minnesota Historical Society,* 5 (1885), 500; Armstrong, "Reminiscences," 289–92; Hall to Ely, December 25, 1850, *EEJ-SHSW,* Vol. 3.

[70] Watrous to Ramsey, November 13 & 14;

n.d. [c. December 12]; & December 30, 1850; in *NAM M234* Roll 767; Ramsey to COIA; December, 1850; in *NAM M234* Roll 767; *HMD 57,* 61.

[71] Ramsey to COIA, November 14, encl., Watrous to Ramsey, November 12, 1850, *NAM M234,* Roll 767; Annuity Records, 20607-#798, Sandy Lake Sub-Agency, December 2, 1850, *RG 75.*

[72] Chippewa Chiefs [of interior] to President Fillmore, [c. November], 1852; and, Chief Buffalo, *et al.,* [of lake shore] to COIA Lea, November 6, 1851; in, *NAM M234,* Roll 149; Watrous to Ramsey, December 10, 1850; W. W. Warren to Ramsey, January 21, 1851; Ramsey to COIA Lea, March 27, 1851; all in *NAM M234* Roll 747. Hall to Treat, December 30, 1850, *ABCFMP-MNHS,* Box 5. H. Hall to L. Burbank, January 14, 1861, *NWMP-UMD,* Box 1, Folder 41; and, Pitezel, Journal Vol. 5, July, 1851, *JPP-CHL.*

[73] Chippewa Chiefs to President Fillmore, and Chief Buffalo, *et al.,* to COIA Lea, cited above. Watrous to Ramsey, December 10, 1850; W. W. Warren to Ramsey, January 21, 1851; Ramsey to Lea, March 27, 1851; all in *NAM M234* Roll 747. "Lake Superior and Mississippi bands Chippewa Chiefs, Sandy Lake Sub-agency, December 2, 1850, Receipt for Provisions," Annuity Records, Item 20607-#798, *RG 75.* Hall to Treat, December 30, 1850, *ABCFMP-MNHS,* Box 5; Hall to L. Burbank, January 14, 1851, *NWMP-UMD,* Box 1, Folder 41. Pitezel, "Journal," Vol. 5, July, 1851, *JPP-CHL.*

[74] Lea to Secretary of the Interior, June 3, 1851, Report Books of the Office of Indian Affairs, *NAM M348,* Roll 8. C. K. Smith (Secretary, Minnesota Territory) to Lea, February 7, 1851; and, Petition of Wisconsin Assembly, February 18, 1851; both in *NAM M234* Roll 767. *LSN&MJ,* June 11 & 18, July 28, & September 27, 1851. P. Greely (Collector of the Customs, Boston), w/encl., Boston news clipping, to Secretary of the Treasury, August 23, 1851, *NAM M234* Roll 149. Watrous to COIA, July, 1851, *NAM M234* Roll 149.

[75] Watrous to Ramsey, September 22, 1851, *NAM M234* Roll 149. See also, COIA to Secretary of the Interior, June 3, 1851, *NAM M348,* Roll 8; Lea to Watrous, 25 August, 1851, *NAM M21* Roll 45; and, Treat to Hall, September 24, 1851, *ABCFMP-MNHS* Box 5.

[76] Watrous survived the charges against him of dereliction in public duty. His patrons in Washington and Minnesota defended him until mid-1852, when he fell under a graver suspicion, of infidelity in political character. It was first claimed, then confirmed, that Watrous had been masquerading under false party colors. As a Minnesota competitor put it on February 28, 1853, he came "on to the Mississippi a rampant Whig. He now pretends to be a strong Democrat." It was an appropriate time for Watrous to adopt this fresh party hue, for Franklin Pierce was to be inaugurated three days later. While this switch did not save him his position as Indian Agent under the new Democratic administration, it did ease the way for his later success in Minnesota. He settled in the Fond du Lac area where he became the Register of the U. S. Land Office, and, after Minnesota's statehood, the first—Democratic—Speaker of the Minnesota Assembly. As he had anticipated in 1850, a tour as Indian Agent was a profitable thing for a young man on this frontier, both financially and as a means of career advancement. See, E. Whittsley to President Fillmore, April 17, 1852, *NAM M234* Roll 149; and November 16, 1852, Roll 767. J. R. Carey, "History of Duluth, and of St. Louis County to the Year 1870," *Minnesota Historical Collections* Vol. 9, 250. S. B. Olmstead to S. B. Lowry, February 28, 1853, in, "John Watrous File," *RG 48.*

[77] Watrous to Lea, June 7, 1852, *NM M234,* Roll 149; Citizens of Lake Superior Petition to President Filmore, June 4, 1852, *NAM M234,* Roll 149; Chief Buffalo to Ramsey, July 23, 1852, *NAM M234,* Roll 428; B. Armstrong, *Early Life Among the Indians,* 26, 30-31, 101. There is no separate confirmation of Armstrong's claims to personal credit for this success. "Treaty with the Chippewa, 1854," Kappler, *Indian Treaties,* 648-52.

[78] *The Last Trek of the Indians* (University of Chicago Press, 1946), 14-15.

[79] Charles Callender calls this the secondary or lesser configuration of Old Northwest Indian patterns in his, "Great Lakes-Riverine Sociopolitical Organization," in Trigger, *Handbook . . . Northeast,* 610.

[80] James A. Clifton, *A Place of Refuge;* J. McClurken, "Ottawa Adaptive Strategies to Indian Removal," *The Michigan Historical Review* (1986), Vol. 12, 29-57.

[81] Callender refers to this as the dominant configuration in the Old Northwest, "Great Lakes-Riverine," 610.

[82] See, Treaties with the Seneca, Shawnee,

and Ottawa, 1831 in Kappler, *Indian Treaties,* 325–39. Also, Prucha, *Great Father,* Vol. 1, 247–48.

[83] James A. Clifton, "From Bark Canoes to Pony Herds: the Great Lakes Transportation Revolution, 1750–1775," *Henry Ford Museum & Greenfield Village Herald* (Vol. 15, 1986), 12–19.

[84] C. G. Klopfenstein, "The Removal of the Indians from Ohio, 1820–1843," Ph. D. diss., Western Reserve University, 1956, 61–62; J. Johnston to L. Cass, February 3, 1824 and April 14, 1825, *NAM MI,* Rolls 14 and 16; "Wapokonetta Council," *Niles Weekly Register,* June 25, 1825; E. W. Duval to Secretary of War Calhoun, November 28, 1824, *NAM M234,* Roll 60; Actg. Governor R. Crittenden to Calhoun, September 28, 1823, *TPUS,* Vol. 19, 549.

[85] Bert Anson, *The Miami Indians* (University of Oklahoma Press, 1970), 213–33, 266–89; S. J. Raefert, "The Hidden Community: The Miami Indians of Indiana, 1846–1940," Ph. D. diss., University of Delaware; Clifton, *The Pokagons.*

[86] R. F. Bauman, "Kansas, Canada, or Starvation," *Michigan History,* Vol. 36, 287–98; Clifton, *A Place of Refuge.*

[87] See, *Great Father,* Vol. 1, 244; compare, James A. Clifton, "Escape, Evasion, and Eviction: Adaptive Responses of the Indians of the Old Northwest Territory to the Jacksonian Removal Policy of the 1830s," TS, paper read at the Conference on the American Indian and the Jacksonian Era, Middle Tennessee State University (1980), 17–18 (Copy on deposit, D'Arcy McNickle Center, Newberry Library, and Wisconsin State Historical Society).

[88] See, H. H. Tanner, ed., *Atlas of Great Lakes Indian History* (University of Oklahoma Press, 1986), 122–125.

[89] E. Whittsley to President Fillmore, April 17, 1852, *NAM M234* Roll 149; and November 16, 1852, Roll 767. Carey, "History of Duluth," 250.

[90] *The Power to Lead: The Crisis of the American Presidency* (New York, 1984), 122.

[91] *Qualitative Science* (New York, 1983), 203–204.

[92] For the later reservation history, see P. Shifferd, "A Study in Economic Change Among the Chippewa of Northern Wisconsin: 1854–1900," *The Western Canadian Journal of Anthropology* 6-4 (1976); and, Danziger, *The Chippewas,* 91–132.

The Aquatic Macrophyte Community of Black Earth Creek, Wisconsin

Roy Bouchard and John D. Madsen

Abstract. *The aquatic macrophyte community of Black Earth Creek, Wisconsin, was studied in June and July of 1985 and compared to data collected in 1981. Macrophyte distribution was examined by the line intercept method, with macrophyte cover negatively correlated to light reduction by tree canopy. The dominant species in the stream was* Potamogeton crispus. *Other species included* P. pectinatus, P. vaginatus, Elodea canadensis, Ranunculus longirostris, Hypericum boreale *and filamentous algae, namely* Rhizoclonium *sp. Average total cover of all macrophytes was 55.6%. Cover of macrophytes was only slightly lower in 1985 than in 1981, which was thought to be due to random population fluctuations rather than directional change in the community. Macrophyte biomass was estimated at three unshaded stations. Maximum macrophyte biomass was 789 g dw* m^{-2}*, with no relation found between biomass and the inflow of a sewage treatment plant. Samples of* Potamogeton crispus *and* Rhizoclonium *sp. analyzed for tissue phosphorus indicated that plants are not near limiting concentrations for P; rather, present data indicate that light availability limits the growth of macrophytes in Black Earth Creek. Oxygen mass balance was used to estimate community photosynthesis and respiration, and the macrophyte/epiphyte contribution to community respiration estimated by* in situ *incubations. Macrophyte/epiphyte respiration contributed 47% to 68% of community respiration. The P/R ratio was 0.62, indicating a heterotrophic stream community.*

Aquatic macrophytes are an important component of stream ecosystems, influencing physical, chemical and biological processes. Aquatic macrophytes stabilize the stream substrate, reducing turbidity and erosion. They also increase deposition of suspended solids, further reducing turbidity, and oxygenate the water by means of photosynthesis. Stream channels deepen and current increases between adjacent plant beds, improving habitat diversity. Aquatic macrophytes and attached epiphytic algae provide food and habitat for macroinvertebrates and other small organisms, as well as protection for large fish species. Macrophytes increase stream productivity beyond energy gained by allochthonous inputs. In addition to these benefits, macrophytes provide surface area for microbes, which contribute significantly to many chemical processes in the stream, such as nitrification, respiration, and decomposition.

However, excess growths of macrophytes can also create problems for the stream ecosystem. Bank-to-bank growths of aquatic macrophytes will slow current velocities, causing flooding and siltation. Homogeneous growths of macrophyte species reduce habitat heterogeneity. Most importantly, excessive plant growths create large daily dissolved oxy-

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gen fluctuations. Nighttime respiration may reduce dissolved oxygen to levels that are stressful or lethal to oxygen-sensitive organisms.

Recent concern for Black Earth Creek centered on potential eutrophication and the resultant effect on this highly productive trout stream. Decisions on the management of plants require some assessment of their distribution, abundance, and impact on the stream. With this in mind, we addressed the following:

1. Species and plant distribution in 1981 and 1985 and their relationship to several physical factors.
2. The relationship between tree canopy, light availability, and plant growth.
3. Macrophyte biomass in Black Earth Creek, with sampling above and below a point source of nutrients.
4. The contribution of macrophyte respiration to the oxygen balance of the stream.
5. Potential phosphorus limitation of macrophyte biomass.

Macrophyte Cover

Previous work (Madsen 1982; Madsen and Adams 1985) on Black Earth Creek surveying the plant communities and physical environment in four sections of Black Earth Creek (Segments 1–4, Figures 1 and 2) indicated that light limitation by tree canopy and turbidity are probably the most important factors limiting plant productivity. The relationship between in-stream plant communities and shading has been extensively studied. Light availability is likely the most important factor limiting plant growth (Dawson and Kern-Hansen 1978; Dawson *et al.* 1978; Krause 1977; Barko *et al.* 1985; Peltier and Welch 1969). The effects of removing the tree canopy were noted by Hunt (1979) in the Little Plover River (Wisconsin), where first year increases in macrophyte cover of more than 200% were seen, with accompanying increases in water temperature and trout production.

Biomass

The actual impacts of macrophytes on the stream environment depend heavily on the amount of plant tissue, or biomass, present in the stream. Methods for estimating plant cover are valuable in allowing rapid quantitative surveys but cannot be used to estimate biomass at higher cover frequencies. Quantification of in-stream biomass is difficult due to the heterogeneity of such systems and the large number of samples needed to obtain statistically meaningful estimates. Recent work in Badfish Creek, Wisconsin (Madsen 1986), indicated that even short stretches (50–100 m) of relatively homogeneous steam may need sample sizes in excess of 15 to 20 samples.

Respiration and Dissolved Oxygen Modeling

Diel variation in dissolved oxygen levels are caused in part by macrophyte photosynthesis (Ps) and respiration (R) (Kelly *et al.* 1983). Macrophytes are only one oxygen consumer in an aquatic system. Bacteria, algae, macroinvertebrates, and higher fauna all contribute to overall respiratory load (McDonnell 1982). Estimates of reaeration coefficients (K2), Ps, and R for the community may be made by finite difference models without detailing their components. Single station models commonly rely on assumptions such as homogeneity of the study reach for some distance above the sampling point, Ps proportional to light intensity, and constant R and K_2 despite changes in temperature (Mace *et al.* 1984, Owens 1966).

Phosphorus Limitation

Unquantified observations of increased macrophyte growth below the sewage treatment plant in Cross Plains caused Brynildson and Mason (1975) to suggest

that P input at that point is responsible. Values reported for total and soluble P for 1985 (WDNR data, unpub.) indicate a substantial input of P due to a point source in the upper watershed. In response to the speculation that phosphorus input to Black Earth Creek may increase macrophyte growth, we analyzed tissue phosphorus from the dominant macrophyte *(Potamogeton crispus)* at several sites to check for limiting tissue P concentrations. In a literature review of nutritional and ecological growth controlling factors, Barko *et al.* (1985) concluded that there are few examples of naturally occuring macrophyte populations exhibiting limitation by phosphorus. Inorganic carbon and physical factors (e.g., light) seem to play a dominant role in limiting aquatic macrophyte growth (Huebert and Gorham 1983; Peltier and Welch 1969).

Work on lake systems (e.g., Carignan 1982; Carignan and Kalff 1979, 1980; Barko and Smart 1981) indicates that sediments provide the bulk of tissue P. Estimates of the sediment contribution to plant tissue phosphorus range from 70 to 100% (Huebert and Gorham 1983). Total removal of P from experimental water columns resulted in unimpeded growth by plants with sufficient sediment nutrients. Mace *et al.* (1984) speculated that the macrophytes in Black Earth Creek utilized sediment P more than water column P, based on a model for other Wisconsin streams.

Literature reports of tissue P in natural populations indicate concentrations ranging from 0.15 to 0.6%. Plants immersed in greatly enriched waters (e.g., Badfish Creek, Dane County, WI) may show concentrations as high as 0.7 to 1.0% P (Madsen 1986). Tissue P levels for all species of plants sampled in Wisconsin by Mace *et al.* (1984) ranged from 0.13 to 0.67%, all of which were above the critical growth level of 0.1% established by Gerloff (1973, 1975).

Methods

Site Description

Black Earth Creek is a highly productive, calcareous stream in western Dane County, Wisconsin (Fig. 1). This limestone stream is classified as a "class-one" trout stream by the Wisconsin Department of Natural Resources (WDNR), indicating that it sustains a population of naturally reproducing trout (Brynildson and Mason 1975). Black Earth Creek is a valuable natural resource to the state, with trout productivity (472 kg ha^{-1} y^{-1}; Brynildson and Mason 1975) nearly as high as the Horokiwi Stream in New Zealand (540 kg ha^{-1} y^{-1}; Allen 1951) and higher than other trout streams studied in the midwest.

Water quality is rated from good to fair, with some water quality degradation related to high concentrations of phosphorus and coliform bacteria (Lathrop and Johnson 1979). Groundwater and artesian spring water maintain low temperatures and high oxygen levels, such as

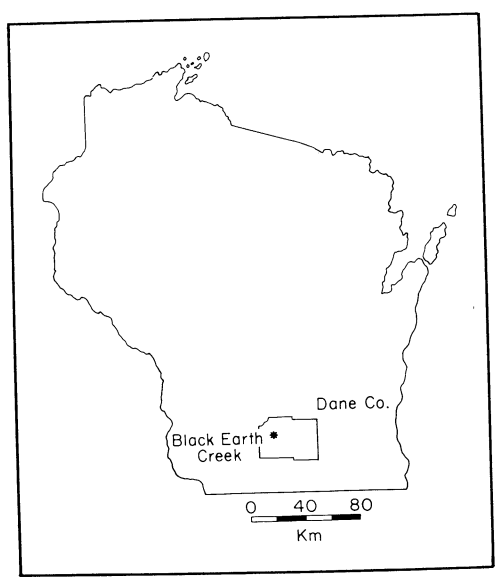

Fig. 1. A map of Wisconsin indicating location of Dane County and Black Earth Creek.

are necessary to support trout and other oxygen-sensitive organisms in Wisconsin (Threinen and Poff 1963).

Black Earth Creek is on the edge of the unglaciated Driftless Area of southwestern Wisconsin. The watershed is largely agricultural (Born 1986). Our study area extends from above the Village of Cross Plains to just above the Town of Black Earth, with seven study sections indicated (Fig. 2). One significant point source of pollution is the Cross Plains Sewage Treatment Plant. However, nonpoint pollution occurs from agricultural activities throughout the watershed as well as urbanization and development in the Village of Cross Plains and the Town of Middleton at the headwaters.

Macrophyte Cover and Physical Environment

During June and July of 1985, four areas previously studied in 1981 were remapped (sections 1–4), along with three additional sections (Fig. 2) to quantify any major changes in macrophyte cover and characterize downstream segments of the creek. Line-intercept methods were consistent with those used in 1981 (Madsen 1982). Once each month, twenty stratified-random transects were sampled in each segment. The transect was placed across the stream, and the occurrence of each macrophyte species in each 1 dm segment recorded. A species found in the 1 dm segment was considered to "cover" that 1 dm segment. Overhead tree canopy was estimated by eye to the nearest 10% at each transect site. Photosynthetically active radiation (PAR) was measured at the stream surface in the center of the channel as well as 1.5 m from each shore using a LiCor quantum meter and probe, with light availability expressed as a percentage of open-field light intensity. Water depth and depth of silt deposits were measured at 1 m intervals, and stream width at each transect. The per-

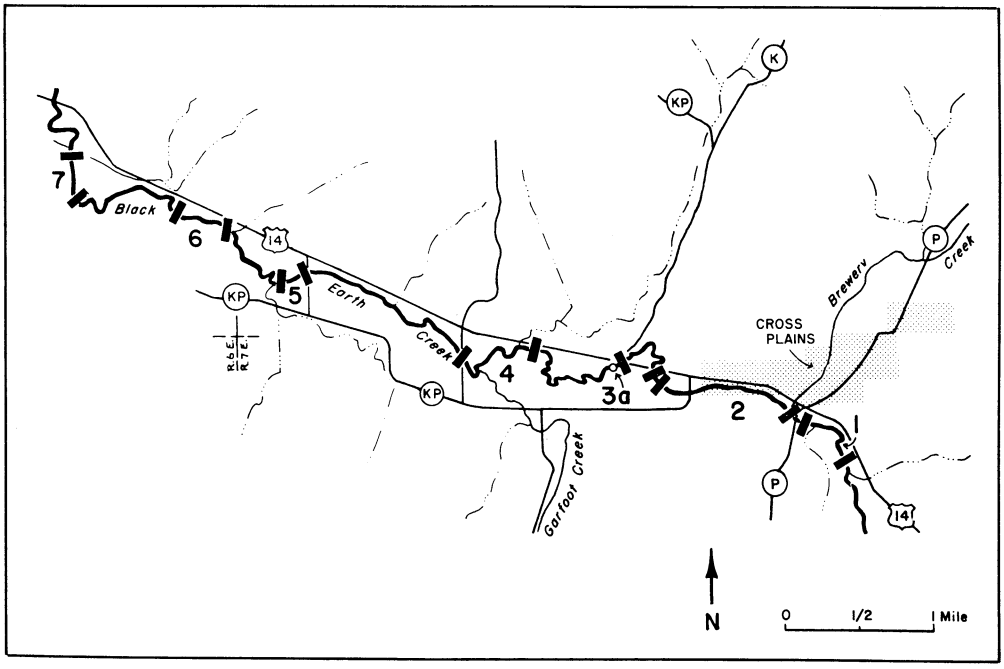

Fig. 2. Map of Black Earth Creek, indicating study sites 1 through 7. Figure reprinted from Water Resources Management Workshop Report (Born 1986).

centage of substrate composed of silt, sand, and gravel at the surface was estimated at each transect.

Biomass

The ability of the stream to support plants was quantified by taking standing crop biomass samples in three representative unshaded areas. Phenological evidence from the literature (Sastroutomo 1981; Kunii 1982) and previous observations on Black Earth Creek (Madsen 1982) suggested plant biomass would peak in early to mid-July. Sampling peak biomass provides a crude estimate of the potential productivity in the stream.

One site within each of three sections (1, 3 and 7) was chosen based on the lack of shade, presence of dense macrophyte growths, and position relative to the sewage treatment plant at Cross Plains. Fifteen stratified random samples were taken from each site. Sites 1 and 7 were 150 m in length; site 3 was 100 m long (Fig. 2). These sites had heterogeneous bottoms of silt over gravel with open channels scoured to bare gravel between dense macrophyte beds. Each sample was harvested from a 0.19 m^2 quadrat at the sediment surface, with inclusion of less than 10% root material. Samples were sorted by dominant species and dried at 70°C. Species identifications and nomenclature follow Fassett (1957).

Respiration and Dissolved Oxygen Modeling

Dissolved oxygen variations of 6–8 mg O_2 l^{-1} observed in the stream over 24-hour periods (WDNR data, unpubl.) prompted a concern for adequate oxygen to sustain sensitive organisms (e.g., trout). The percentage contribution of macrophytes and attached epiphytes to the whole stream respiration of one area of Black Earth Creek was estimated to indicate the role of macrophytes in community oxygen depletion.

A single station model developed by Mark Tusler (WDNR) was applied to Site 1 (Fig. 2). Temperature and dissolved oxygen data (uncorrected probe readings) were obtained from the U. S. Geological Survey (USGS) from the gaging station at Cross Plains (downstream end of Site 1) for June 12–14. Simultaneous temperature and dissolved oxygen measurements were taken at 8 A.M. and 2 P.M. at each end of the study stretch on June 13. Low variation in temperature (less than 0.2°C) and dissolved oxygen (less than 0.1 mg O_2 l^{-1}) indicated uniformity of the water mass in the stretch, a necessary requirement to satisfy the assumptions of the single station model utilized.

Dark respiration estimates for the dominant macrophytes (*P. crispus* at site 1 and *P. vaginatus* at site 7) were done on June 13 and 14 with a total of 12 replicates for each species. Twenty cm terminal sections of healthy shoots were incubated *in situ* in 300 ml BOD bottles (taped to exclude light) for periods of 2–3.5 hours, along with stream water controls. Dissolved oxygen concentrations were determined by the azide modification of the Winkler method (APHA Standard Methods 1981). Plants were removed from the bottles immediately after acidification and dried to constant weight at 70°C. Subsamples were used to determine total ash content at 550°C. No attempt was made to remove epiphytes prior to incubation because these contribute directly to respiration as part of the macrophyte-epiphyte complex in the stream.

Phosphorus Limitation

Following the rationale of Gerloff (1973), composite samples of the 10 cm terminal segments of healthy *P. crispus* shoots were randomly harvested on June 20 from all study sites (excluding site 5, which had little growth of *P. crispus*). Additionally, a sample of filamentous algae was harvested from site 6. Samples from

each site were oven-dried, ground in a Wiley mill, and split samples analyzed by the vanadomolybdate procedure (APHA *Standard Methods* 1981) in our laboratory and by the Wisconsin State Laboratory of Hygiene.

Results and Discussion

Macrophyte Cover

The physical environment in Black Earth Creek is heterogeneous with respect to depth, current, and substrate. These three interrelated factors have a large impact on plant distribution, resulting in highly variable species distribution and abundance. The stream channel widens considerably downstream, increasing from 4.9 m in site 1 to 12.9 m just above Black Earth. The width/depth ratio averages 16.5:1, and also increases in a similar fashion (Table 1). Much of Black Earth Creek is composed of relatively uniform runs broken up by short riffles and pools.

Figure 3 shows the relative distribution of silt, sand, and gravel covering the bottom of the sections surveyed. While the base materials of the stream are gravel and cobbles, silt deposits have altered the character of the substrate throughout the stream, with considerable depths of silt deposited in places (up to 1 m). Sections 3 and 4 were the only ones that had greater than 60% gravel substrate and were similar in width/depth ratios. Downstream sections 5 and 7 had 30% or more sand deposits. Silt deposits were moderately correlated with plant cover ($r = 0.4$, $p < 0.001$). Average depths of silt by site are listed in Table 1. Observations indicate that while depths of sediment as great as 80 cm build up in places along the stream edges, much of the areal distribution is made up of shallower (ca. 10 cm) deposits held in place by macrophyte beds. Mace *et al.* (1984) found a 69% (presence/absence) occurrence of macrophytes on silty substrates. Kullberg (1974) also noted the increased frequency of macrophytes on silt substrates. Dense beds of *R. longirostris,* which is usually located on gravel/cobble substrate, commonly trapped 10 cm or more of sediment where the plants were not located directly in a riffle area. Previous observations on Black Earth Creek (Madsen 1982; Madsen and Adams 1985) of *P. crispus* rooting in silt over gravel tend to confirm the impression of its significant local impact on deposition. Macrophytes cause local sedimentation within a plant bed by reducing current velocities (Haslam 1978; Gregg and Rose 1982; Madsen and Warncke 1983). Although moderate siltation may cause a favorable substrate rich in nutrients for macrophyte growth, heavy siltation causes burial and decomposition of macrophyte beds. Therefore, the

Table 1. Averages for environmental factors for study reaches 1 through 7 for June and July.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*all reaches*
% Light	91.8	71.4	29.6	55.6	100	47.1	100	67.1
% Canopy	7.8	33.2	59.2	27.5	0	49.7	0	28.8
Width (m)	4.9	6.1	6.5	8.5	11.2	10.1	12.3	8.1
Depth (cm)	69	45	43	48	38	42	55	49
Width/Depth	7.1	13.6	15.1	17.7	29.5	24.1	22.4	16.5
% Silt	74.7	38.7	15.3	25.9	14	16.2	33.2	32.2
% Sand	5	12.1	5.1	2.2	33.5	27.1	34.8	15.3
% Gravel	20.6	47.6	79.6	71.9	52.5	56.7	32	52.4
Silt Depth (cm)	35	22	10	15	10	16	34	22

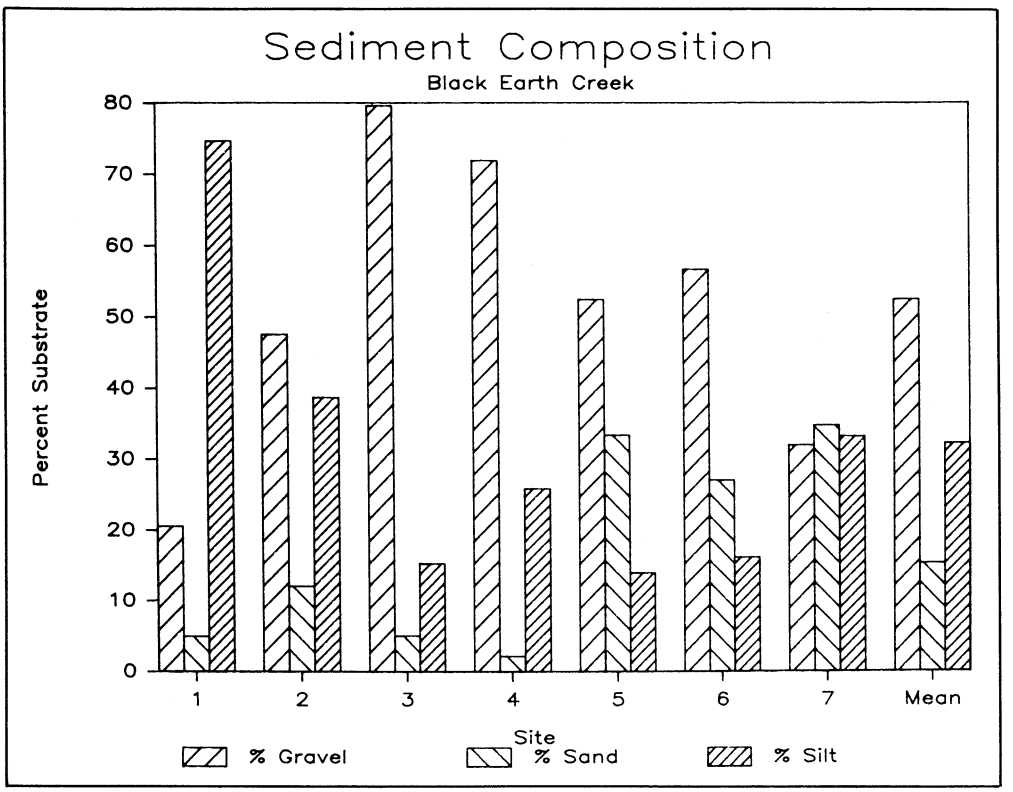

Fig. 3. Substrate composition in percent gravel, sand and silt for study reaches, and mean for all reaches.

higher frequency of macrophytes on silt substrates may be caused by increased siltation in a macrophyte bed, in addition to favorable current velocity or substrate conditions.

The average cover of macrophytes for all seven sites was 55.6% (S.E. = 2.1) for June and July combined. The average for sites 1 through 4 was 60.4%, compared to the 1981 estimates of 68.8% (Fig. 4). Section-to-section variability is high between and within years, especially in section 1. The major change from 1981 is an average decrease in the abundance of the dominant, *Potamogeton crispus*. However, this is most likely due to annual variation rather than directional change in the community.

The community in 1985 was composed of seven species that together made up more than 96% of total cover (Fig. 5). One of the notable differences from 1981 was the scarcity (< 1%) of formerly dominant *N. officinale,* and the relative abundance of *H. boreale,* with 4% cover. In addition, *P. vaginatus* occurred with *P. pectinatus* in similar abundance, especially at site 7. A striking growth of filamentous algae identified as *Rhizoclonium* sp. began in late June and covered large areas of site 5, which previously showed very little vegetation despite its lack of shading. The site is shallow with primarily gravel substrate and scattered *R. longirostris* patches providing anchoring substrate for the usually periphytic filaments. Localized patches of dense filamentous algal growths were also encountered at sites 3, 4, and 6 in shallow areas with exposure to sunlight. Filamentous algae were not quantified in 1981. The increased importance of *Elodea, Potamoge-*

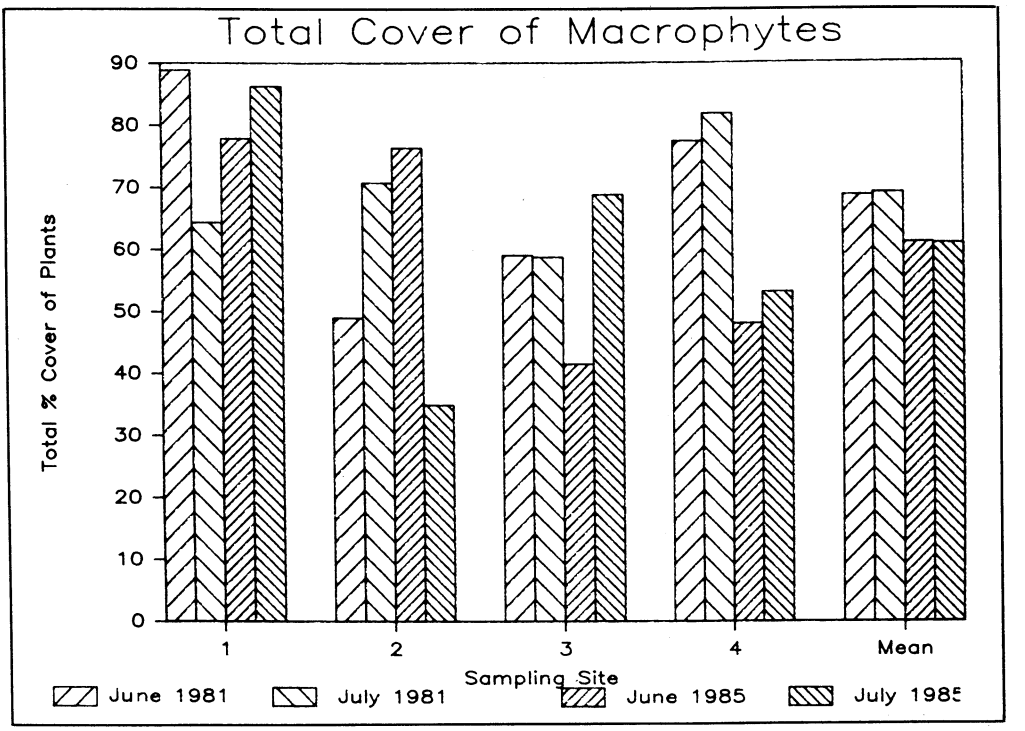

Fig. 4. Percent total community cover in Black Earth Creek for June and July of 1981 and 1985.

ton vaginatus and *Ranunculus* in 1985 versus 1981 is largely due to sampling of the lower reaches (5, 6, and 7) in 1985 that were not sampled in 1981. Similarly, the much higher relative percentage of *P. crispus* in 1981 is in part due to the sampling of only sections 1 through 4. *Potamogeton pectinatus* and *P. vaginatus* are much more prevalent in section 7. A smaller amount of variation in species composition between the two years is due to interannual fluctuations in dominance (Dawson *et al.* 1978).

Overhead canopy was negatively correlated with percent cover of macrophytes ($r = -0.58$, $p < 0.001$) and with the percentage of ambient light reaching the stream surface ($r = -0.87$, $p < 0.001$). This indicates that shading reduces cover and biomass development by significantly reducing in-stream light intensity. The average width of the stream (8–10 m) is narrow enough for effective shade control of aquatic vegetation.

Control of stream macrophytes by shading has been extensively studied and utilized in European streams (Dawson 1978; Dawson and Haslam 1983; Krause 1977; Jorga *et al.* 1982). In Wisconsin, (Madsen 1986) found a 60% reduction in incident light and a 50% reduction in macrophyte biomass in areas of Badfish Creek with natural tree vegetation, as compared to areas with only herbaceous riparian cover. Riparian shading by either naturally propagated or planted tree cover could be a feasible control technique for Black Earth Creek macrophytes. Control of macrophytes should only be implemented if the macrophyte standing crop is considered to be detrimental to the oxygen balance of the stream community.

Over shorter periods of time, light availability in Black Earth Creek may be

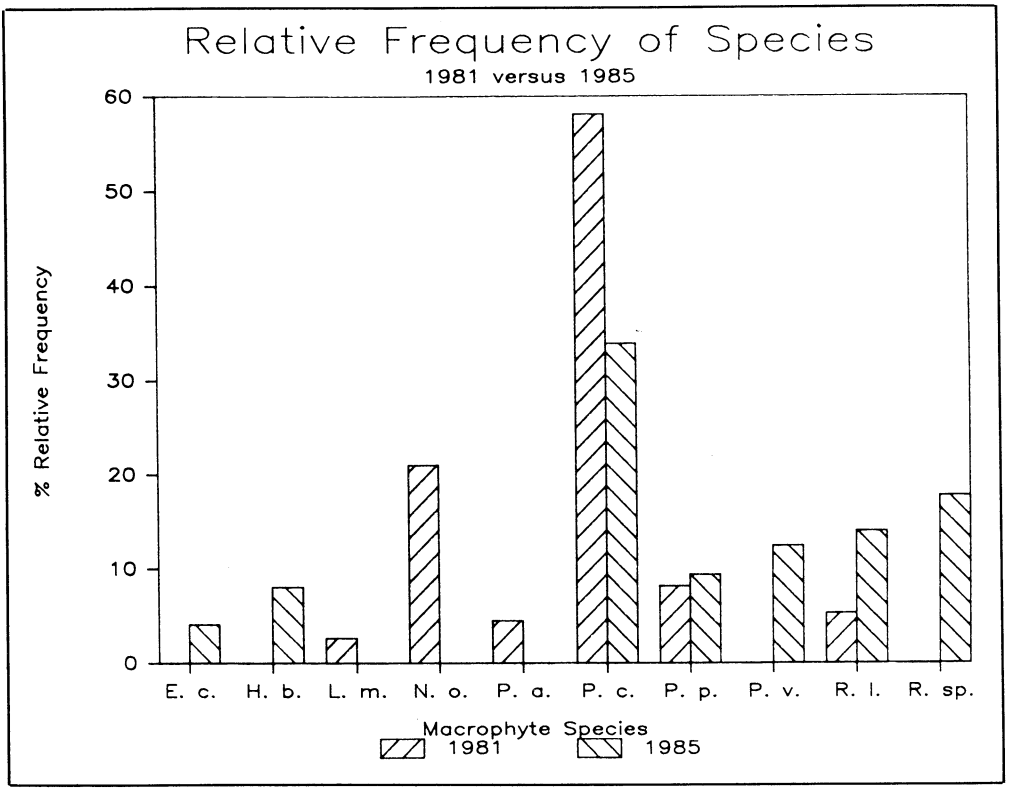

Fig. 5. Relative frequencies of species for 1981 and 1985; E. c., Elodea canadensis; *H. b.,* Hypericum boreale; *L. m.,* Lemna minor; *N. o.,* Nasturtium officinale; *P. a.,* Phalaris arundinacea; *P. c.,* Potamogeton crispus; *P. p.,* Potamogeton pectinatus; *P. v.,* Potamogeton vaginatus; *R. l.,* Ranunculus longirostris; *R. sp.,* Rhizoclonium *sp.*

reduced by water turbidity. Periods of heavy runoff may create turbid conditions for many days, or even weeks (pers. obs.). Variability in turbidity from year to year is one contributor to interannual variability in macrophyte biomass.

Biomass

Biomass provides an estimate of the ability of Black Earth Creek to support macrophyte growth (Table 2). Areas of high biomass and dense growth occurred in and above site 1, indicating that the stream is highly productive well before it encounters the point source of nutrients at Cross Plains. The input of treated sewage effluent from the Cross Plains Sewage Treatment plant does not increase macrophyte biomass, but may stimulate the growth of periphytic algae. Biomass at sites 1 and 7 may be higher than site 3 because of edaphic factors, specifically higher percentage silt. Data from both 1981 and 1985 show site 3 to have lower total cover, due to both different sediment characteristics and higher percent tree canopy.

Biomass sampling was done on Black Earth Creek by Mace *et al.* (1984) in September, 1982 at a location 11 km downstream from Cross Plains yielding an estimate of 282 g m^{-2}. This estimate does not truly reflect potential biomass on Black Earth Creek, since the sample was taken after the senescence of the dominant species *(Potamogeton crispus, P.*

Table 2. Above-ground biomass of macrophytes at three sites in Black Earth Creek (July 1, 1985).

Site	Mean Crop $g\ m^{-2}$	Standard Error	% of species by weight*					
			R	P.c.	P.spp.	H.b.	R.l.	E.c.
1	789.4	92.7	—	45	—	22	10	23
3	334.8	27.0	—	19	—	—	—	81
7	512.1	62.9	4	—	96	—	—	—
MEAN	545.4							

* Species codes: R = *Rhizoclonium* sp. and other filamentous algae; P.c. = *Potamogeton crispus;* P.spp. = *P. pectinatus* and *P. vaginatus;* H.b. = *Hypericum boreale;* R.l. = *Ranunculus longirostris;* E.c. = *Elodea candensis.*

pectinatus and *P. vaginatus).* A maximum biomass range of 500 to 800 g dw m^{-2} is more reasonable and is comparable to values reported for fertile limestone streams in Britain, as well as other streams (Table 3). Mace *et al.* (1984) found an average biomass of 365.5 g dw m^{-2} for Mount Vernon Creek, a nearby stream that receives less point and non-point pollution. Peak values for Badfish Creek, a nearby stream receiving sewage effluent, were 700 g dw m^{-2} in 1983 and 626 g dw m^{-2} in 1984 (Madsen, in prep.). The similarity of values between Black Earth Creek and Badfish Creek support our contention that the macrophytes in these streams are not nutrient limited.

Respiration and Dissolved Oxygen Modeling

Respiration estimates for *P. crispus* and *P. vaginatus* averaged 2.43 and 2.90 mg 0_2 g $AFDW^{-1}$ h^{-1}, respectively (S.E. was 0.59 and 0.14, corrections for AFDW were 0.854 and 0.843). While these are higher than the suggested value of 1.5 mg 0_2 g dw^{-1} h^{-1} as suggested by Westlake (1966), they compare well with values found for similar species by Mace *et al.* (1984) and our unpublished data for *P. pectinatus.* Respiration attributed to microbial and algal activity in the water column was estimated to average 4.3 mg 0_2 1^{-1} d^{-1}, which is approximately 10% of the whole stream respiration estimated below.

The model estimated K_2 (adjusted to 25 C) at 8.52 d^{-1} and Ps and R as 25.1 and 40.7 mg O_2 1^{-1} d^{-1} respectively. The estimated K_2 appears high compared to the estimates of 8.5 to 10 d^{-1} by Grant and Skavroneck (1983) for an area downstream of Cross Plains that has a higher gradient and shallower flow than site 1. However, the K_2 calculated had a rather large confidence interval (5.9–11.1 95% C.I.), and thus the disparity with the expectations based on the results of Grant and Skavroneck is not surprising. Lack of

Table 3. Macrophyte biomass for representative streams and lakes.

Community	Species	$g\ m^{-2}$ Biomass	Reference
Fox Lake, WI	*Potamogeton pectinatus*	293	Kollman & Wali 1976
River Ivel, UK	*Berula—Callitriche*	520	Edwards & Owens 1960
River Test, UK	*Ranunculus pseudofluitans*	385	Owens & Edwards 1962
River Ivel, UK	*Ranunculus pseudofluitans*	320	Owens & Edwards 1962
River Yare, UK	*Potamogeton lucens*	381	Owens & Edwards 1962
River Chess, UK	*Callitriche* sp.	322	Owens & Edwards 1962
Bear River Delta, Man.	*Potamogeton pectinatus*	517	Robel 1961
Lake Suwa, Japan	*Potamogeton crispus*	86.8	Ikusima 1970
Badfish Creek, WI 1983	*Potamogeton pectinatus*	700	Madsen 1986
Badfish Creek, WI 1984	*Potamogeton pectinatus*	626	Madsen 1986

correction in the model for temperature effects may produce an overestimation of K_2. MacDonnell (1982), working on a highly productive hardwater stream in Pennsylvania, noted that K_2 may be overestimated by as much as 27% in such situations.

Effects of dissolved oxygen changes on respiration are probably small, as the observed range was between 6.8 and 13.9 mg 0_2 1^{-1} for the period. This is above the level (5 mg 0_2 1^{-1}) at which large effects on respiration are noted (MacDonnell 1982). Model assumptions about the uniformity of the stream flow can be questioned on the basis of USGS data on groundwater input. Flow may be augmented approximately 40% in the area. While information on the dissolved oxygen content of groundwater is limited, estimates used by a Waste Load Allocation Study in 1977 (WDNR, unpubl.) were approximately 8 mg 0_2 1^{-1}. Input of oxygenated water would tend to reduce calculated rates of respiration with a consequent overestimation of the proportion of macrophyte respiration to total community oxygen usage.

Using the biomass estimate for site 1 of 789.4 g m^{-2} (Table 2) and a conservative estimated respiratory rate of 1.5 mg 0_2 g dw^{-1} h^{-1} (Westlake 1966), macrophyte community respiration would be 28,418 mg 0_2 m^{-2} d^{-1}. Model whole stream R estimated as 40.7 mg 0_2 1^{-1} d^{-1} and an average depth of 0.67 m yields 60,430 mg 0_2 m^{-2} d^{-1}. Thus, a conservative estimate of macrophyte respiration may account for about 47% of the daily ecosystem respiration in the study section. Our respiration estimates for *P. crispus* were somewhat higher than the value suggested by Westlake, so that 68% of community respiration might be due to macrophytes if all species at the site had similar respiration rates to *P. crispus*.

The overall P/R ratio of 0.62 would classify Black Earth Creek as an heterotrophic stream ecosystem, meaning that it is a net consumer of oxygen and theoretically uses more allochthonous than autochthonous energy. This value is within the ranges noted by Hannan and Dorris (1970). While this stream is highly productive on a seasonal basis, the combined respiratory activity of biota require more oxygen from the stream than was produced during this period. While a P/R <1 is surprising in light of the lush growth and healthy condition of the plants at the time of the trials, the model estimates of other small streams commonly produce similar results (M. Tusler, pers. comm.). Small streams are net consumers of dissolved oxygen, and naturally variable faunal production during the season often produces heterotrophy in productive streams (Hynes 1970). A seasonal analysis of P/R may show a great deal of variability in P/R over the year. The P/R ratio may be greater than one during winter, spring and early summer due to low respiratory biomass and low temperatures. As macrophyte (and periphyton) biomass increases, self-shading occurs so that only the upper portion of the macrophyte canopy exhibits net oxygen production, but all of the biomass respires, creating a mid- to late summer depression of the P/R ratio to less than one (Naiman and Sedell 1980). Autumnal P/R will remain below 1 due to decomposition of senescent macrophytes and allochthonous input of deciduous tree leaves. Therefore, a one-time measurement of P/R does not indicate the overall character of a stream as a net producer or consumer of energy and oxygen, but it does indicate whether the stream is a net consumer of oxygen in the summer—the time of critical oxygen levels for sensitive organisms.

Phosphorus Limitation

Table 4 indicates the location of samples and the mean values of tissue P

Table 4. Tissue phosphorus concentrations in Black Earth Creek *Potamogeton crispus* or *Rhizoclonium* sp.

Site/ location	[P](%)	Number of Samples
1 Mid-site	0.89	2
2 Below Brewery Cr.	0.56	1
2 Above CP STP	0.81	1
3 Below CP STP	0.83	1
3 Downstream end	0.87	1
4 Upstream end	0.75	1
4 Scherbel Rd.	0.73	1
6 Mid-site	1.03	1
6 *Rhizoclonium*	0.53	1
7 Mid-site	0.64	2

found. Samples run by both laboratories yielded results within 5% of each other. Macrophyte tissue P values found were significantly above limiting critical concentrations, indicating that P is not limiting macrophyte growth. Although rooted vascular macrophytes are able to take up P from the water column via the shoots, the bulk of P is usually taken up by the roots from the sediment (Carignan and Kalff 1979, 1980; Carignan 1982; Barko and Smart 1981; Huebert and Gorham 1983).

Tissue P concentrations of filamentous algae were lower than those for *P. crispus,* but were still substantially above critical concentrations exhibited for Cladophoran species. Work done on filamentous algae indicate a range of tissue P critical concentrations for growth from approximately 0.06% *(Cladophora glomerata)* to 0.18% *(Draparnaldia plumosa)* (Gerloff 1975; Gerloff and Krombholz 1966; Neil and Jackson 1982).

While growth-controlling levels and dynamics of P in *Rhizoclonium* are not known, extension of knowledge of *Cladophora* is reasonable. These genera are closely related, possibly even variants of the same genus. Thus, nutritional and other physiological requirements may be quite similar (Linda Graham, pers. comm.). Investigations of Great Lakes *Cladophora* growth would indicate that *Rhizoclonium* in Black Earth Creek is not limited by P concentration in the water column (Canale and Auer 1982; Auer and Canale 1982a,b). Moore (1977) found that filamentous algae in British streams were regulated more by temperature and light than nutrients.

Dense growths and rapid spread of filamentous algae were observed in early July. Temperature conditions and light are probably optimal at this time of year for Cladophoran algae based on responses of related species in the Great Lakes (Graham *et al.* 1982; Lorenz and Herrendorf 1982) and flowing waters (Moore 1977).

Summary

Although percent cover was lower in 1985 than 1981, no significant change in total community cover or composition was detected. *Potamogeton crispus* remained the dominant macrophyte in this community. Filamentous algae were not quantified in the 1981 study, but personal observation indicates that there has been an increase in noticeable filamentous algal colonization.

Tree canopy significantly reduced incident light levels at the stream surface and was thus correlated with decreased macrophyte cover. These data suggest that light is a significant limiting factor to macrophytes in this stream and that shading by streambank trees may be potentially useful in the control of macrophytes.

Biomass in unshaded areas ranged from 335 to 790 g dw m^{-2}, indicating that the Cross Plains Sewage Treatment Plant does not increase macrophyte biomass, as the highest value was found above the treatment plant.

The estimated respiratory contribution to the stream ecosystem of the epiphyte-macrophyte complex was 47 to 68%. This

suggests that macrophytes contribute a substantial proportion of the in-stream oxygen demand wherever their growth is dense. If oxygen levels are considered to be seriously depleted in such areas, the control of rooted vegetation by shading may be the only feasible remedial action available. Filamentous algae would also respond to control by shading.

Dramatic growth of filamentous algae in the stream this year prompts questions as to its impact on oxygen levels. Control of algal growth may be amenable to reductions of P from point sources since algae acquire nutrients solely from the water column, but important questions remain to be answered as to the nonpoint levels of P available and whether in-stream levels could be reduced below limiting concentrations for filamentous algae. Our tissue P data indicate that the algae are not limited by P availability. Phosphorus removal from the sewage treatment plant at Cross Plains is unlikely to have an impact on the growth of either rooted macrophytic vegetation or filamentous algae.

Macrophyte growth in Black Earth Creek is probably controlled by dynamics other than phosphorus limitation. Macrophyte tissue samples analyzed were well above critical concentrations, exhibiting luxury uptake. We reject the notion that macrophyte growth in Black Earth Creek is responding to point source nutrient enrichment, particularly that of phosphorous, because (1) biomass at separate sites bears no relation to point sources of nutrients, (2) plant tissue P concentrations show no evidence of P limitation, and (3) biomass levels found in Black Earth Creek are similar to those found in calcareous streams in other areas of Wisconsin, the United States, and Britain—streams that have a broad range of impacts from human enrichment, from near-pristine to heavily polluted.

The impact of macrophyte-induced sediment deposition in the stream has not been adequately addressed, especially as it affects space and reproduction potential for fish. Optimum values for macrophyte cover have not been estimated in this respect or in regard to spatial requirements of fish or food production.

Aquatic macrophytes provide many benefits to the stream ecosystem, including those used as trout fisheries. However, anthropogenic disturbance of the watershed may cause excessive growths of macrophytes with deleterious effects on natural ecosystems.

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Edgar B. Gordon: Teacher to a Million

Anthony L. Barresi

Each year millions of Americans receive instruction via radio and television. In fact, we take for granted the availability of children's programming such as "Sesame Street," and we expect broadcasters to give us "how to" courses in cooking, home repair, and even remedial mathematics. If questioned we readily acknowledge the importance of media instruction, and yet we give little thought to how such teaching is accomplished. We in this state would be surprised to learn that many of these media instructional approaches were pioneered in Madison by Edgar B. Gordon of the University of Wisconsin. This article will chronicle his professional career and will focus primarily upon the adaption and implementation of the teaching techniques that he developed specifically for radio instruction.

Born in 1875 in Frankfort, Indiana, Gordon received the largest part of his early education in the Winfield, Kansas, public schools. After his graduation from high school in 1893, he moved to Chicago where he studied violin at the Chicago Musical College. In 1900 he became a resident director at the Chicago Commons Settlement House, a satellite of the famous Hull House. Gordon's experiences working with the city's immigrant poor and disenfranchised led him to view music as did the settlement movement's founder, Jane Addams, "as a potent agent for making the universal appeal and inducing men to forget their differences" (Addams 1910). As a result of his choral work in the settlement house, Gordon's interest for teaching music to underprivileged segments of society was whetted. This interest would later influence his innovative activities in community arts and radio instruction.

In 1907, the Gordons moved to Los Angeles to work at the College Settlement, but they soon resolved to return to Chicago. Enroute, the young family stopped to visit family who convinced them to remain in Winfield. Shortly after, Edgar was hired to teach violin and theory for the Winfield College of Music and to organize and conduct a college-community orchestra at Southwestern College (Mullet 1983). Over the next few years Gordon found himself "pretty much in control of the musical resources of the community" (Gordon Papers).

The young music educator achieved some national prominence when, in 1913, Winfield received official state recognition as the Kansas community that could "offer the best environment for raising children." The judges noted that they were impressed with the "unusual manner and degree in which the fine arts were integrated into the life of the community"—a direct reference to those artistic activities influenced by Edgar Gordon (Gordon Papers).

Good Housekeeping Magazine asked Edgar to write an article about the Win-

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field award for the December 1915 issue (Mullet 1983). This article attracted the attention of Peter Dykema of the University of Wisconsin Extension who invited Gordon to deliver a paper on the Winfield activities at the 1916 meeting of the Music Supervisors National Conference. Dykema, a noted figure in American music education, also prevailed upon Edgar to accept a position with the University of Wisconsin Extension faculty as Director of Community Music and Drama (Gordon Papers). In 1921, Gordon became head of the School Music Department in the University's School of Music, a position he held until his retirement in 1944 (University of Wisconsin Employment Records).

Early Radio Efforts

WHA Radio, one of the first radio stations in the nation, resulted from combined efforts of dedicated University of Wisconsin physics researchers and public-spirited programmers. While this station's claim to primacy is disputed, its assertion that it is the oldest American radio station in continual operation is commonly acknowledged. Beginning with the 1915 experimental transmissions via "wireless telegraphy," radio technology grew swiftly through the work of Professor Earl M. Terry and a number of his students. By 1920, WHA was broadcasting daily reports of weather and road conditions as well as farm information (McCarty 1937). That year, Professor Terry, imbued with the Wisconsin Idea concept, engaged Professor W. H. Lighty of the Extension Division to expand service broadcasting activities (Axford 1960). These two men prevailed upon Edgar Gordon in 1921 to present a music program that would eventually evolve into a music appreciation instruction over the radio—likely the first media instruction in the nation and possibly in the world. Using recordings and some guest artists, Gordon instituted

First Music Appreciation Broadcasts (c. 1922).

weekly broadcasts in which he sought to play some "good music and make some explanatory comments that might be helpful in enjoying the music" (Gordon Papers). After the adoption of a more formal instructional format in 1922, Gordon routinely introduced each piece by discussing its composer, the musical form, its historical development and the performing artist(s) (Penn 1940). Within this format he created a Chautauqua lecture hall illusion in the minds of the listeners who, for the most part, were in awe of the medium. The station received letters from listeners living in areas as far away as Montana and Canada. A group of women in Kearney, Nebraska, even used the weekly program as the basis for their music appreciation study (Gordon Papers).

To adapt the lecture hall format to the purely aural radio medium, Gordon developed several unique approaches. First, he exploited the imaginal potential of radio and secondly, he sometimes used on-site participants as "stand ins" for the listening audience. Gordon recounts the employment of both of these techniques during a 1922 Independence Day broadcast. After a patriotic address by a member of the history faculty, Gordon led the radio audience in the singing of America—"a first in the history of radio," he claimed. To encourage the audience to participate, he stimulated their collective imagination by asking them to consider themselves as part of a "great unseen chorus" expressing their patriotic fervor. In order to reinforce this imaginal technique and to provide a vocal model for the listener-singers, he used a small group of studio singers as an on-site chorus. Such commonly employed techniques might appear rather naive to us, but it is highly probable that the July 4th broadcast marked the first time that such approaches were used to encourage active listener participation. Gordon recounted

E. B. Gordon and early studio group (Minnesingers).

E. B. Gordon and Minnesingers visiting children.

that listener response to this broadcast was very enthusiastic. A highly supportive letter from one of the "unseen chorus" is still retained in the State of Wisconsin Archives (Lighty Papers).

Gordon's early efforts in radio instruction were recognized when, in the late 1920s, he was asked to serve as an advisor for the famous Walter Damrosch music appreciation broadcasts for children. As a result of this experience he discovered that active student participation was preferable over passive listening in order that varying attention spans of children and their need for physical involvement while learning be accommodated. Moreover, his experiences as a performer and conductor led him to believe that a child's active interaction and involvement with "good music" was an effective means for developing musical understandings and a lifelong interest in music (Gordon Papers). Gordon's later programming for children reflected this understanding and conviction in the instructional techniques and materials used.

Other Broadcast Experiments

Several radio experiments further honed Gordon's technique for media teaching and advanced the efficacy of radio instruction. In 1929, he and A. F. Wiledan of the University's Rural Sociology Department conducted a radio experiment that for its time was truly unique. Gordon conducted a rehearsal of a 100-voice chorus in Viroqua, Wisconsin from the studio in Madison! Using a twenty-voice choir in the studio, the Professor conducted the rehearsal with them while the Viroqua choir sang along. Because the off-site ensemble could not observe his conducting gestures, Gordon used simultaneous verbal cues to inform them of his musical intent (*Capital Times* press clipping). Later he would often use

the verbal cue technique in his programs for children to compensate for the visual limitations of the radio instruction.

In 1930, Gordon, as chairman of the University of Wisconsin Radio Research Committee, devised a project in which his music education students taught music over the radio to twenty-five classes of sixth, seventh, and eighth-grade children. A control group was taught the same material in a standard classroom setting. Comparisons of test results from the radio students and control group convinced Gordon that radio teaching could be a very effective means for music instruction. This project also gave him the opportunity to develop and implement teaching approaches and materials specifically designed for radio teaching (Gordon 1931).

Journeys in Musicland

When WHA station manager Harold B. McCarty conceived the idea for a School of the Air in 1931, he approached Gordon for advice because he remembered the Professor's earlier experimental projects in radio instruction. Gordon expressed the belief that programming for children should be devised that would "assist classroom teachers in the teaching of subject areas for which they were minimally trained." As music was a subject area typically neglected in most rural

E. B. Gordon conducting a radio festival.

schools, McCarty encouraged Gordon to develop a music instruction program (McCarty interview, February 3, 1984). And thus were initiated the "Journeys in Musicland" broadcasts so popular with several generations of children from rural Wisconsin between the years 1931 and 1955.

In these weekly music lessons Professor Gordon taught songs, some basic music theory, and a "considerable amount" of music appreciation. The aim was to "stimulate the interest of children in good music and to cultivate the ability to participate in some form of music activity" (WHA program schedule, September 1933–January 1934). But it took a while before all of these learning activities were included in the programs. For the first few, he confined the activities to listening experiences. Then Gordon began tentative efforts to secure some reaction from the listeners such as responses to rhythm. When his classroom observers reported the apparent success of these action-based approaches, the Professor decided to attempt the teaching of a song. But he was not content that the children should "merely mouth the words"; rather he wanted singing that was tonally pleasing and accurate—difficult goals considering that he could not hear the sung responses to his instructions.

> . . . I finally decided to try. I chose a lovely German folk song which I first asked the children to listen to while it was beautifully sung by a university student. Then I asked the children to hum along while it was sung again. The third time through, the children were instructed to follow along, this time using the syllable "loo," On the fourth singing the words were used (Gordon Papers.

After teaching several songs in this manner Gordon went into the schools to check the results. To his great pleasure, the performance of the children revealed that they were indeed singing with pleasing tone and pitch accuracy.

Two innovative teaching techniques, which might have contributed significantly to this instructional success, are revealed in the Gordon description. First, his selection of a light female voice that closely resembled that of a child provided an aural model for the listeners to emulate. Secondly, while his approach to teaching the rote song was similar to that commonly used during the 1930s, Gordon's adaption for radio was aurally conceived and methodically moved the children from passive to active participation. Simply stated, he encouraged close concentration while listening to the first rendition and gradual performance participation as familiarity with the song was gained. By the "fourth singing," familiarity with the words and music was sufficient and a successful performance was possible (Dvorak interview). Over the course of a year he would teach about twenty songs in this manner and would review them frequently so that they remained fresh in the minds of the children.

The song material taught by Professor Gordon was drawn from two major sources. The largest number of songs were chosen from folk music of Great Britain, America, Scandinavia, Germany, the Slovak nations, Italy, Spain, Mexico, and France—all ethnic groups represented in the population of Wisconsin. The other source of music of "lasting value" was pieces by major composers of symphonic, opera, oratorio, or lieder literature. When adaptions of text were necessary, his wife Edna Gordon acted as lyricist (Gordon song books, 1940–1955).

As the years progressed and the educational goals of the "Journeys" program gained more focus, Gordon made a number of changes in the instructional format. In order to create a classroom atmosphere in the studio, he used a group of singers

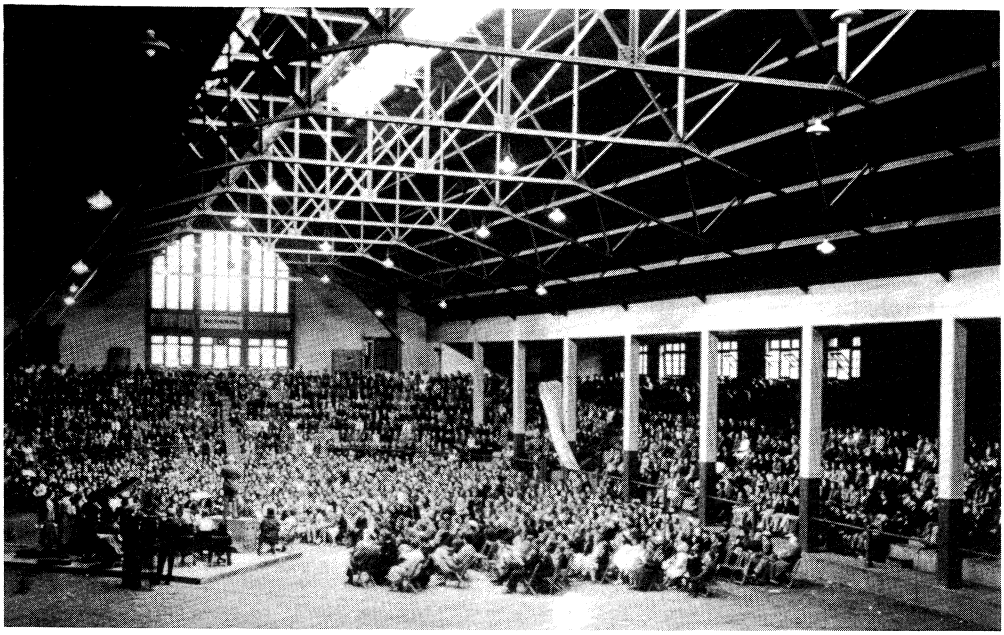
(later named the Minnesingers) who modeled good singing tone for the children and also acted as an on-site class. Evidently, Gordon was drawing upon the "unseen chorus" and "radio choral rehearsal" experiments as sources for this instructional approach. He also developed instruction books that contained all of the songs for the year's programming and music theory information and exercises. These books provided the visual reinforcement that was missing in the purely aural instruction, and they presented additional information that could be studied between programs, should the teacher be so inclined. At first the books were mimeographed, but by 1940, they were published by WHA and sold to the children at cost (Bartell interview). To this day one may still find these song books in the homes of numerous Wisconsin families.

Gordon's previous broadcast experiences had appraised him of the medium's power to stimulate the imagination. He drew upon this potential whenever he created the illusion that the young listeners were part of the class occurring in the studio. Teachers of participating students told the author that the children often felt that the professor was talking directly to them when he admonished "the boy in the red sweater to open his mouth more" or "the girl in the front row to sit up straight when she sings" (Pischke interview). By cultivating a fatherly image that correlated well with his short, rather plump stature, white hair, and kindly sounding voice, Gordon created a radio personality that was loved and respected by the children (Pickart interview).

Gordon further exploited the illusionary powers of the medium and his own charisma by making effective use of the analogy in the teaching of musical concepts and music reading understandings. He often encouraged the performance of crescendo and decrescendo by likening the increase and decrease in dynamics to climbing and descending a mountain. When explaining the relationships of scalar pitches to each other, he would often draw comparisons to relationships common to the experiences of the children. On one occasion he characterized each scale pitch as a neighbor in a child's neighborhood with the first pitch (key pitch or tonic) as home and the eighth pitch (the same tonic pitch one octave higher) as the home of grandparents. He then taught the intervalic relationships of the pitches to the tonic pitch by having the children "visit" (sing) the various neighbors and return home (tonic pitch) from time to time. By effectively employing analogies that stimulated the mind's eye, Gordon was able in another way to compensate for the radio's visual limitation ("Journeys in Musicland" audio tape recording).

Finally, the use of spoken instructions under the singing to give directions or in anticipation of a musical problem was a favorite instructional technique. Ruth Pischke, one of the Professor's studio accompanists, relates that he often gave verbal directions to the children while conducting the studio "class" and that he often joined in the singing to reinforce difficult melodic passages, awkward phrase structures, or tricky rhythms.

While it is difficult to attribute the development of these instructional approaches solely to Gordon, that he adapted them to accomplish his purposes and pioneered in their use is certain. The successes that he achieved by the uses of these instructional approaches within the "Journeys" format are evidenced by the astonishing enrollment figures. In the first year (1931), 793 students participated and in 1955, the last year under Gordon, 70,000 children were registered. Over the twenty-four year period, 1,028,125 Wis-



Radio festival (1940s), 3000 children.

consin children participated in this weekly program (WHA Data Sheet)!

Radio Festivals

The sociological concern that began in the settlement movement of Chicago, and subsequently colored all of his professional career activities, found its ultimate expression in the yearly radio festivals sponsored by WHA. Because the Professor wanted "his children" to experience the "ultimate social experience of music making," he devised the idea of bringing children to Madison for a day to sing together the songs that they had learned in the radio lessons. Such gatherings also gave him the opportunity to better evaluate the effectiveness of his teaching (McCarty interview, June 6, 1986).

From the first festival held in the University's Old Music Hall and attended by 300 children (1934) to those of the 1940s and 50s attended by over 3,000 participants, the response to these gatherings was overwhelming. Increased enrollments over the years caused moves from Old Music Hall to the Stock Pavilion and finally to the largest of the University's facilities, the Field House. When enrollments were so large that the largest auditorium on the campus could no longer accommodate those wishing to attend, the station management and Gordon decided to bring the yearly festival to the children (McCarty interview, Feb 3, 1984). During the mid-1940s the radio professor began to hold festivals in various centers around the state as well as in Madison. By 1956, fifteen festivals were held for about 22,300 children throughout the state (WHA Radio. *The First Fifty Years,* 1969). Recordings of some of these festivals reveal that the children sang with expression, precision, accurate intonation, pleasing vocal quality, and dynamic variation. Obviously, the radio teacher had achieved much more than "just the mouthing of words."

Edgar B. Gordon's radio music teaching represents a unique chapter in Wis-

consin's history. Receiving no remuneration for any of his radio work he sought out the musically underprivileged children of rural Wisconsin and administered to their aesthetic needs with the zeal of a social reformer. He was a man who learned from his experiences and one who possessed the creative talent and personal charisma to implement his ideas effectively within the unique educational environment of the Wisconsin Idea. Indeed, the entire state was his classroom.

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Notes from the Notebooks of Cabin #3

"you are incarnate in
the world and we live
caught up in you."

Teilhard de Chardin

"The wicked are like the troubled sea
when it can not rest"

Isaiah 57:20

"one honeymoon day
one honeymoon night
nothing else to say
nothing else to write"

Anonymous

Everyone mentions the "waves," of course,
and the "crying" of the gulls
and the "moon," through the one small window,
"full," "half," or otherwise
provocatively sickled against
a "starry" or "starless" sky,
or as Helen Rusted, of Fond du Lac, put it:

"the thriving mysteries of life
unfolding in waves of time
spiriting through
the vast existence in space."

Many honeymooned or re-honeymooned here,
most are thankful for the change
from whatever to whatever,
everyone goes on almost endlessly
about the peace and quiet.

"we have been married four days
we love each other very much
didn't get seasick listening to the waves

through faith in the lord
we will be married forever."

"do we sound boring,
we don't think we are?"

They had "wieners and cheese for breakfast" or
"crackers and cheese for breakfast lunch and dinner"
or "champagne and meatballs by candlelight"
or "picked blueberries for pancakes
and raspberries in big dishes with cream."

"Had some nice fresh herring."
"hot cookies and milk just out of the cold."

"In this just right cabin,
the carefully watched toast made
on the top of the stove."

The lake was a lullaby, or not.
They loved or hated the bed
which was not "big enough for three"
according to "Don & the girls,"
which was "noisy but
sure held up," "Figgy and Ray,"
in which they slept, if at all,
like a "stone" a "cloud," a lot of "log's"
a "baby" or "the dead."

"We found #3 by pure luck
almost got rammed by a semi."

"The evening of the 19th my wife
got stomach flu
and I got the regular flu
the day after that day."

"fell off the cliff
and lost my shoe but
it could have been worse."

"We came here to be alone
married three years already with a little girl.
This Shawnee's handprint (slightly enlarged)
5 mos. old, 1st time anywhere"

Mrs. Anthony Swanshera of St. Paul
will be back "if I can talk my husband into it,"
and Ginny, Eddie, Lionda, Edvart and Tottsie
are planning to return, in three years,
"God willing."

"We came to find ourselves once more
to remember that what we need
we have already in each other."

"We used to come here as children
now we have children
and grandchildren of our own
and we are still coming"

"We are in or '70's
and it makes a good honeymoon spot"

"We loved each other tenderly
and our fondness increased
as we grew old."

"I sat on the rocks, smoking,
and her reading to me
in the pleasing wild."

"Cassie found the notebooks
and as she read
years and faces came alive."

"It has been good
watching this plan unfold,
creating wholeness
in our life."

Bruce Taylor

note: The quoted material was selected from a series of "guestbooks" dating back to 1937 found in a rental cabin in a small resort on the North Shore of Lake Superior in 1986. People were asked in the original notebook to write whatever they wanted, and provide another when the current one was full.

Diel Patterns of Behavior and Habitat Utilization of Cisco *(Coregonus artedii)* in Two Wisconsin Lakes

Lars G. Rudstam and Todd W. Trapp

Abstract. *Diel patterns of behavior and habitat utilization of cisco* (Coregonus artedii) *differed between lakes and among age groups. At night, cisco were dispersed across both lakes, but three different daytime distributions were observed: cisco were (1) dispersed and distributed across the lake (older fish in Trout Lake), (2) schooled and distributed across the lake (Pallette Lake), and (3) schooled and distributed closer to shore (younger fish in Trout Lake). No diel vertical migration was observed, but the smaller fish in Trout Lake moved toward the shore during dawn and offshore during dusk. Stomach analyses indicate that cisco may feed both day and night. Younger cisco were spatially segregated from older fish in Trout Lake, but there were only small differences in diet between the two groups. Possible causes for differences between lakes and between age groups are discussed.*

Pelagic fishes in lakes often exhibit diel patterns of behavior and habitat utilization. Vertical migrations toward the surface at night are common in planktivorous salmonines (Narver 1970, Eggers 1978) and coregonines (Northcote and Rundberg 1970, Dembinski 1971, Nilsson 1979, Enderlein 1982, Hamrin 1986). However, Engel and Magnuson (1976) did not observe any vertical migration of cisco *(Coregonus artedii)* in Pallette Lake, Wisconsin, during summer stratification. Instead, they reported a horizontal diel migration. The fish moved onshore at dawn and offshore at dusk. Horizontal diel migrations of coregonines have not been reported elsewhere, but such migrations have been observed for percids (Hasler and Bardach 1949, Hasler and Villemonte 1953), cyprinids (Hall et al. 1979, Hanych et al. 1983, Brabrand et al. 1984), and centrarchids (Baumann and Kitchell 1974).

Engel and Magnuson attributed the lack of vertical migration of cisco in Pallette Lake to the narrow depth interval where temperatures were low and oxygen levels high enough to support cisco (the "cisco layer" of Frey 1955). Vertical migrations would then be expected in larger, deeper lakes with well-oxygenated hypolimnia. In this paper, we present results from an investigation of cisco diel behavior in two northern Wisconsin lakes (Trout and Pallette Lakes) during summer stratification, using sonar and vertical gill nets. We address the following questions: (1) is the horizontal diel migration pattern reported from Pallette Lake consistent over a period of time, (2) can this pattern be found in another lake, and (3) does vertical diel migration occur when the hypolimnion is deep and well oxygenated (Trout Lake, temperatures below 10° C and oxygen levels above 3 mg/l from 12-

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m to 30-m depths). In addition, we report data on diel feeding patterns obtained from analyses of stomach content of fish caught during different time periods.

Study Area

Pallette and Trout Lakes are located in Vilas County in Wisconsin's Northern Highland Lake District (46.0°N, 89.7°W). Pallette Lake is a 69 ha seepage lake with a mean depth of 9.7 m and a maximum depth of 19.8 m. It has a low alkalinity (0.15 mmol/l) and can be considered oligotrophic. Trout Lake is a 1605 ha drainage lake separated into four basins. Our investigation was conducted in the largest and deepest of these basins with an area of 770 ha, a mean depth of 18 m, and a maximum depth of 35.7 m. Trout Lake is more productive than Pallette and has an alkalinity of 0.82 mmol/l.

Materials and Methods

Pallette Lake was investigated on 13–15 July 1981 and Trout Lake on 10–12 August, 17–18 August, and 2–3 September 1981. The lakes were surveyed with a 70 kHz echo sounder (Simrad EY-M, 11° beam width) during day, night, dawn and dusk periods. The transducer was towed 0.3–0.5 m below the surface from an "A-frame" in front of a small boat. Towing speed was approximately 1.5–2 m/s. Transects were made along the longest diameter of the lake and perpendicular to this diameter.

Seven 4-m wide multifilament vertical gill nets were used for the catch, each with a different mesh size (19, 32, 38, 51, 64, 89 and 127-mm stretch mesh). The seven nets were set in a straight line for 48 hours from the surface to the bottom along the 14-m depth contour in Pallette Lake (13–15 July) and along the 18-m depth contour in Trout Lake (10–12 Aug.). Trout Lake was fished for an additional 24 hours with 32-mm and 38-mm mesh nets suspended from the surface and with 19, 51, 64, 89 and 127-mm mesh nets suspended from 13-m depth to 28-m depth (17–18 Aug.). The nets were serviced approximately every six hours (Table 1). Fish were identified and their length measured. Depth of catch was noted in 1-m intervals. When available, 10 fish of each 1-cm-length class were weighed in the field using a spring balance. Stomachs

Table 1. Median depth of catch for young-of-year (0+), I+ to II+, and older cisco in Trout Lake. The 25 and 75 percentiles are given in parentheses. Sunrise at 0455, 11 August, and 0503, 17 August. Sunset at 2114, 11 August and 2105, 17 August.

Time period		*Evening*		*Night*		*Morning*		*Day*	
Age group	*Depth sampled (m)*	*median*	*N*	*median*	*N*	*median*	*N*	*median*	*N*
10–12 August: Time		1600–2130		2130–0325		0325–1000		1000–1600	
0+	0–18	—	0	14 (14–14)	2	—	0	—	0
I–II+	0–18	15 (15–15)	3	16 (14–17)	12	15 (7–17)	3	—	0
older	0–18	16 (15–16)	3	14 (14–16)	14	15 (12–15)	5	—	0
17–18 August: Time		1630–2200		2200–0730				0730–1630	
0+	13–28	17	1	14 (13–18)	12			19 (19–19)	4
I–II+	0–28	18 (12–19)	13	16 (14–19)	33			—	0
older	0–28	26 (22–27)	19	26 (22–27)	26			26 (25–26)	16

from Trout Lake cisco were removed in the field and preserved in 10% buffered formalin.

Settled volume of the stomach content was measured using tapered centrifuge tubes. An index of stomach fullness was obtained by dividing the settled volume by fish weight calculated from a length-weight regression for Trout Lake cisco ($W = 1.3\ 10^{-5}\ L^{2.9}$, weight (W) in g, length (L) in cm, N = 117, range 10–22 cm). This index was not correlated with fish weight ($r = -0.11$, $N = 95$, $P > 0.10$). Prey groups were identified and counted in a subset of the stomachs with a binocular microscope with 6 to 50 times magnification.

Results

Cisco constituted 97% of the total catch in gill nets in Pallette Lake and 87% in Trout Lake. The other species caught, yellow perch, *Perca flavescens,* was always netted above 7-m depth. We therefore considered all targets on echo charts in water deeper than 7 m to be cisco.

All cisco were caught between 7 m and 13 m in Pallette Lake (143 fish) and between 7 m and 28 m in Trout Lake (171 fish). The four cisco caught during the day in Pallette Lake were in the same square meter of netting at 9-m depth. In the deeper part of Trout Lake, cisco larger than 190 mm total length (III + and older, Rudstam 1984) were caught significantly deeper than younger cisco (Table 1 and 2, Fig. 1).

The sonar charts revealed that cisco were dispersed (not schooled) during the night (indicated by many dispersed echoes in Figs. 2 and 3). At dawn schools were formed both in Pallette Lake and by the shallower, younger fish in Trout Lake. No vertical migration was observed in either lake. The schools broke up at dusk (Figs. 2 and 3). In Pallette Lake, these schools were distributed across the lake whereas in Trout Lake they congregated in areas closer to shore. These diel distribution patterns were consistent among replicate sonar transects (4 day, 4 night, 2 dawn and 2 dusk transects in Pallette Lake; 14 day, 14 night, 4 dusk and 4 dawn transects in Trout Lake). The total absence of smaller cisco in gill nets during the day in Trout Lake (Fig. 1) is also consistent with sonar observations. Older cisco in Trout Lake were caught in deep water both day and night, and sonar charts show dispersed echoes in the deeper water throughout the 24-hour period. No vertical or horizontal migration was observed. The absence of daytime schools of larger cisco could be explained by low light levels (which ranged from 0.1 to 10 mc at 25-m depth in Trout Lake, August 1981, J. Magnuson, unpubl. data). The schools of several fish species disperse at these light levels (see review by Blaxter 1979).

Table 2. Comparison of depth distribution of different size classes of cisco in Trout Lake, Wisconsin. The samples from all time periods are combined for each group of fish.

Comparison 1 versus 2	*Depth interval used in analysis (m)*	*Mann-Whitney Z-score*	*P*	N_1	N_2
10–12 August:					
0-II + older	0–18 m	0.60	N.S.	20	22
17–18 August:					
0 + I-II +	13–28 m	1.08	N.S.	17	41
0 + older	13–28 m	5.10	<.001	17	58
I-II + older	0–28 m	7.18	<.001	47	61

Stomach-fullness index (settled volume/fish weight) for cisco in Trout Lake did not vary significantly between time periods except for the comparison between morning and night samples from 10–12 August (Table 3). We found what seemed to be newly ingested material in stomachs from fish caught both night and day, and our attempts to classify the degree of digestion in 54 stomachs did not yield significant differences between time periods. Thus, we could not detect any clear diel feeding peaks; cisco in Trout Lake appeared to feed day and night.

The diet was dominated by small zooplankton (copepods and cladocerans) and *Chaoborus* larvae and pupae (Table 4). This is similar to earlier reports (Couey 1935, Engel 1976). Differences were small in diet composition between older cisco caught during day and night as well as between older and younger cisco.

Table 3. Stomach fullness index (stomach fullness/fish weight, in mm^3/g) of cisco caught during different time periods in Trout Lake. Fish over 140 mm total length are included. Only night and morning 10–12 August are significantly different (Mann Whitney Z-score: 2.39, $P < 0.02$).

	Stomach Fullness Index		
10–12 August Time period:	Evening	Night	Morning
Median	8.2	3.6	8.4
Range	0.9–9.0	0.9–11.0	2.5–12.4
Fish length (mm)	146–204	148–205	149–207
N	6	21	8
17–18 August Time period:	Evening	Night	Day
Median	10.5	9.1	9.5
Range	1.0–17.6	0.8–22.5	2.4–21.4
Fish length (mm)	144–216	146–226	195–232
N	15	28	17

Discussion

Our observations show that cisco diel patterns of behavior and habitat utilization during summer stratification may differ both between lakes and between age groups and may change with time within a lake. At night, cisco were dispersed across

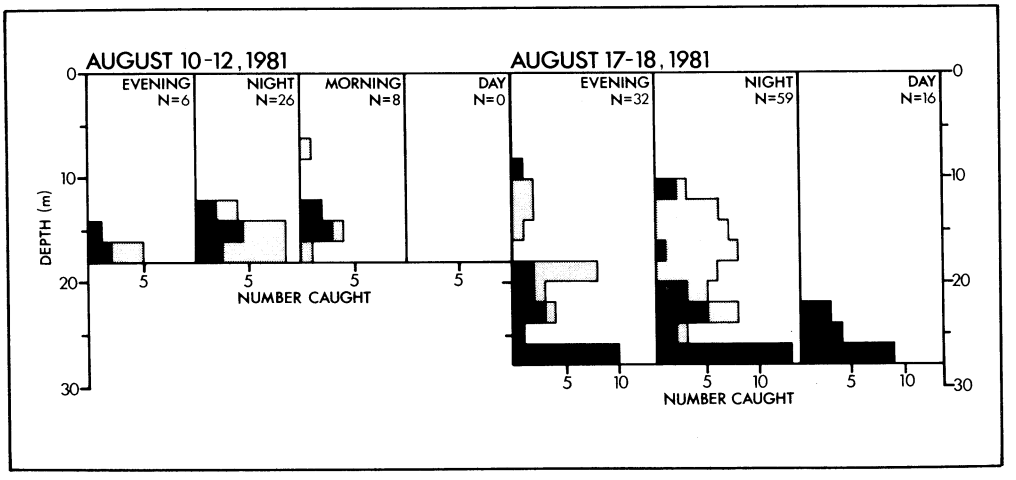

Fig. 1. Depth distribution of cisco I+ and older caught in vertical gill nets in Trout Lake, Wisconsin. The cisco are separated into fish smaller than 189 mm (age I–II+, dotted bars) and fish larger than 190 mm (age III+ and older, solid bars). Except for one fish, all cisco I+ and older were caught in the 32- and 38-mm stretch mesh nets. These nets were set from the surface to bottom (18-m depth, 10–12 August and 28-m depth 17–18 August).

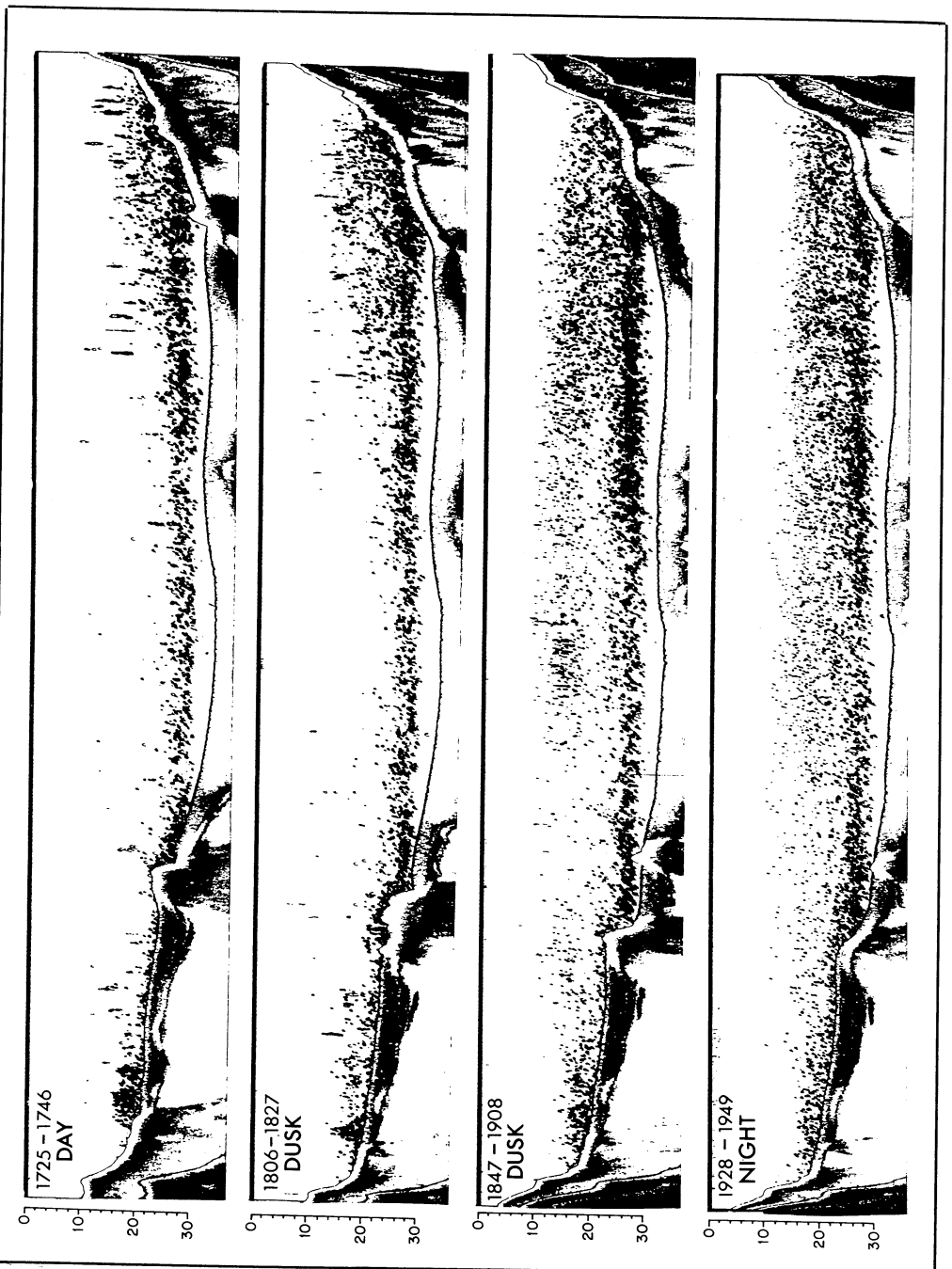

Fig. 2. Sonar charts from 2 September 1981 from the deep basin of the southern part of Trout Lake, Wisconsin. The weather was clear and calm. An eighth moon was up. Sunset was at 1938 CST. Each transect is approximately 2.5 km long.

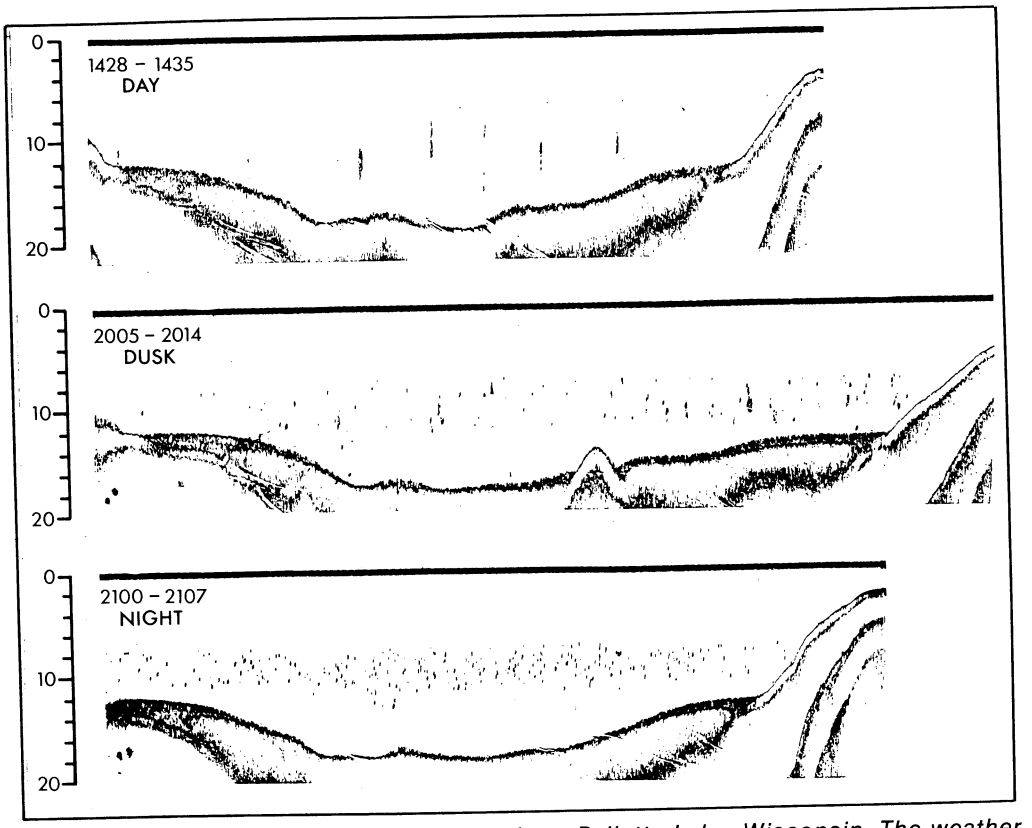

Fig. 3. Sonar charts from 14–15 July 1981 from Pallette Lake, Wisconsin. The weather was overcast and calm with light rain. Sunset was at 1945 CST. Each transect is approximately 500 m long.

both lakes. This can also be observed in other Wisconsin lakes (Big Muskellunge and Sparkling Lake, Vilas Co.; Lake Mendota, Dane Co., Rudstam 1983). However, day distributions differed both between the two lakes and between cisco age groups. Three patterns were observed: (1) fish dispersed and distributed across the lake (older cisco in Trout Lake), (2) fish schooled and distributed across the lake (Pallette Lake), and (3) fish schooled and distributed closer to shore (younger fish in Trout Lake). No diel vertical migration was observed in either lake. Younger cisco in Trout Lake moved toward the shore at dawn and into the middle of the lake at dusk. A similar horizontal migration was observed in Pallette Lake in 1969–70 (Engel and Magnuson 1976) but did not occur in that lake in July 1981.

These observations show that the horizontal migration pattern described by Engel and Magnuson (1976) was not an isolated occurrence. But neither is diel horizontal migration the rule for cisco. Changes in the open water fish community of Pallette Lake between 1969–70 and 1981 indicate the possible importance of inter-specific interactions in regulating diel migration patterns. Large numbers of perch occurred pelagically in Pallette Lake in 1969–70, when cisco migrated horizontally. These perch had an opposite diel movement to cisco, toward the shore at dusk and back to the pelagic zone at

Table 4. Diet of cisco from Trout Lake. Median number of identifiable food items in stomachs for different size classes and time periods are listed. The range, percent by number in the diet, number of stomachs where a food item occurred, and depth of catch are also given.

Date and time period *Age group*	*Aug. 10–12, Dusk-Dawn I–II +*			*Aug. 10–12, Dusk-Dawn III + and older*			*Aug. 17–18, Dusk-Dawn III + and older*			*Aug. 17–18, Day III + and older*		
Food item	median (range)	%[d]	N[e]	median (range)	%	N	median (range)	%	N	median (range)	%	N
Calanoid copepods	2 (0–31)	17	10	2 (0–63)	19	8	230 (0–1604)	42	10	26 (3–570)	21	14
Cyclopoid copepods	12 (2–64)	39	12	6 (0–69)	33	12	216 (32–856)	29	11	40 (4–1840)	40	14
Harpactacoid copepods	0 (0–1)	0.6	3	—	0	0	0 (0–44)	0.4	1	9 (0–604)	12	10
All copepods[a]	30 (3–95)	72	12	7 (0–132)	56	12	556 (212–3047)	89	11	118 (11–2260)	92	14
Daphnia spp.	0 (0–12)	4	5	0 (0–23)	7	3	50 (4–320)	10	11	8 (0–74)	3	11
Other cladocerans[b]	0 (0–2)	0.6	2	0 (0–1)	0.2	1	—	0	0	—	0	0
Ostracods	—	0	0	—	0	0	0 (0–8)	0.01	1	0 (0–2)	0.1	4
Chironomidae[c]	0 (0–2)	1	3	0(0–2)	0.6	4	—	0	0	0 (0–1)	0.01	1
Chaoborus[c]	4 (0–60)	22	10	8 (0–103)	36	11	3 (0–82)	1	10	19 (0–144)	5	12
Fish length (mm)	146–189			191–207			190–216			202–216		
Number of stomachs	12			13			11			14		
Depth of catch (m)	7–18			12–18			22–30			22–29		

a) includes unidentified copepods
b) includes Bosmina spp. and Chydoris spp.
c) includes both larvae and pupae
d) % by number in diet
e) number of stomachs containing the food item

dawn. Engel and Magnuson (1976) suggested that the opposing movements of the two species enhanced spatial niche separation. In July 1981, pelagic perch were rare (only four perch were caught in the gill nets), and cisco did not migrate horizontally.

Vertical diel migrations did not occur even though cisco were not restricted by high temperatures and low oxygen levels to a narrow depth layer in Trout Lake. This differs from observations on vendace (*Coregonus albula,* a related Eurasian cisco), which is generally reported to migrate vertically (Northcote and Rundberg 1970, Dembinski 1971, Nilsson 1979, Enderlein 1982, Hamrin 1986). Vendace feed primarily during daylight hours (Nilsson 1979, Enderlein 1982) and may increase the length of its feeding period by migrating toward the surface at dusk. Since cisco can feed at night (Engel 1976, Janssen 1980), diel vertical migrations may be less advantageous.

Although the diel migration patterns of cisco and vendace differed, both species show intra-specific habitat segregation between age groups (Rudstam and Magnuson 1985, Hamrin 1986). The similarity in diet of different cisco age groups (Table 4) indicates that this segregation was not due to an age-specific preference for different food items that may have been differentially distributed in space. Different size groups of vendace also have similar diets (Hamrin 1983). Hamrin (1986) suggested that younger vendace are more efficient planktivores than larger vendace and that larger fish therefore avoid younger fish to decrease intra-specific food competition.

Engel (1976) reported cisco as feeding during the night, and Emery (1973) classified this species as a nocturnal planktivore. However, neither of these two studies compared fish caught during day and during night. Our somewhat limited data does not support a nocturnal feeding peak. Cisco in Trout Lake appeared to feed both day and night. This is in accordance with laboratory experiments by Janssen (1980) on cisco feeding both in light and in darkness. The fish were size-selective and more efficient in light. However, feeding occurred in darkness even at the lowest prey density tested (16 *Daphnia*/l). The fish were then nonselective. As Janssen points out, the possible effect of cisco predation on zooplankton communities depends on the time of day they feed. This predator-prey interaction is further complicated when diel patterns of habitat utilization exist (e.g. younger cisco in Trout Lake). Cisco may act as daytime size-selective planktivores in part of a lake and as nighttime nonselective planktivores in other areas.

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Nineteenth-Century Temperature Record at Fort Howard, Green Bay, Wisconsin

Joseph M. Moran and E. Lee Somerville

Abstract. *Fort Howard (located near the present site of Green Bay, Wisconsin) was one of several nineteenth-century army posts in the Old Northwest that participated in the nation's first weather observing network. From late 1821 through mid-1841, and from late 1849 to mid-1852, medical personnel at the fort maintained a nearly continuous log of daily weather conditions. A comparison of monthly and annual mean temperatures suggests that recent months and years in Green Bay were generally cooler than the 1820s and 1830s at Fort Howard. However, several factors may affect the validity of this comparison. Specifically, concern surrounds the accuracy, exposure, and location of the Fort Howard thermometer, differences in methods of computation of mean temperatures, and the reliability of Fort Howard's weather observers. Of these, instrument exposure is probably the most troublesome factor for it appears likely that at times Fort Howard's thermometer was exposed to direct sunlight. Such instrument exposure would invalidate comparisons with the modern temperature record.*

Fort Howard, located near the present site of downtown Green Bay, Wisconsin, was a member station of the nation's first weather observing network. In the early to mid-1800s army medical personnel stationed at the fort dutifully maintained a log of daily weather conditions, providing us with a fascinating glimpse of climate for a period when such information was sparse throughout much of the North American interior. Comparison of the Fort Howard temperature record with the modern temperature record at Green Bay suggests that the recent era was somewhat cooler than the earlier era. The principal objective of this study is to assess the validity of that comparison. While there is little reason to question the reliability of Fort Howard's weather observers or the accuracy of the thermometer in use, differences in weather observing practices between then and now pose more serious problems. Of these, differences in instrument exposure appear to be most significant and may well invalidate any comparison between temperatures at Fort Howard and Green Bay.

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The Surgeon General's Weather Network

Because the War of 1812 with the British revealed weaknesses within the medical service of the United States Army, the newly appointed Surgeon General, James Tilton, M.D., set about in 1813 to reorganize the service by drawing up a new set of duties and regulations for all army medical personnel. As part of that reorganization, on 2 May 1814, Tilton issued an order that, in retrospect, marked the first step in the eventual

establishment of a national network of weather observing stations (Hagarty 1962). Tilton directed the army medical corp to maintain a diary of weather conditions at army posts with responsibility for weather observations falling to the post's chief medical officer or surgeon. Tilton's objective was to learn more about the climate encountered by troops in the then sparsely populated interior of the continent. He also wanted to assess the relationship between weather and health for it was a popular notion at the time that weather and climate were important factors in the onset of disease.[1]

It took time for Tilton's order to be implemented. The War of 1812 was still raging, and weather instruments had to be acquired and distributed along with directions for proper use. Benjamin Waterhouse, M.D., surgeon at Cambridge, Massachusetts, was the first to submit weather data (for March, 1816). By 1818, reports of weather observations at several army posts began trickling into the Surgeon General's office, and under the direction of Tilton's successor, Joseph Lovell, M.D., the data were compiled, summarized, and eventually published (Lawson 1840). For this reason Lovell rather than Tilton is sometimes credited with being the founder of the government's system of weather observation (Landsberg 1964).

At first, a thermometer and wind vane were the only weather instruments in use at the army posts. The chief medical officer or his assistant read the thermometer daily at 7 A.M., 2 P.M. and 9 P.M. (local sun time), and noted the day's prevailing wind direction and weather conditions. In a column labeled "remarks," comments were entered concerning the health of the troops, phenological events, and any extreme or unusual weather. In 1836, many posts (including Fort Howard) were supplied with rain gages (DeWitt-type) along with very precise instructions on the proper siting and use of the instrument. Rainfall or melted snowfall was measured in inches (to 0.01 in.) at the end of each precipitation. Also beginning in 1836, prevailing wind direction and weather conditions were recorded for both morning and afternoon.

In 1842, the Army Medical Board, in consultation with some of the era's leading scientists, selected and issued new weather instruments along with revised and somewhat more sophisticated observation procedures (Mower 1844). These new procedures were adopted widely in January 1843 (1849 at Fort Howard), and except for observation times the instructions are similar to those issued to today's cooperative weather observers. Temperature, cloud cover (in tenths), and wind direction were recorded four times daily: at sunrise, 9 A.M., 3 P.M., and 9 P.M. The wet bulb thermometer was read at sunrise and 3 P.M., and at some army posts barometer readings also were recorded. Later, in 1855 the Surgeon General's Office shifted observation hours back to 7 A.M./2 P.M./9 P.M., convinced that these observation times gave a better estimate of daily mean temperature.

Medical personnel entered weather data in a journal each day, and quarterly summaries (January-March, April-June, July-September, and October-December) were prepared and then forwarded to the Army Medical Department in Washington, D.C. Tabulations of weather data from all army posts were later published as a series of *Meteorological Registers* (Lawson 1840, 1851, 1855).

By 1838, 16 army posts had compiled at least 10 complete—albeit not always successive—years of weather data. In ensuing years the number of military weather observing stations climbed steadily,

[1] Bates and Fuller (1986) point out that in wartime, even as late as World War I, more soldiers died from non-combat causes (disease, primarily) than from battle.

reaching 60 by 1843, and by the close of the Civil War, weather records had been assembled for varying periods at 143 locations. By the 1870s the Surgeon General's weather network and those operated by the Smithsonian Institution and the U.S. Army Corps of Engineers were merged gradually into a single weather observation network within the Army Signal Corps. Eventually, this new network evolved into the present National Weather Service (Hughes 1980).

Evaluating the Fort Howard Temperature Record

Fort Howard's weather record was among the earliest and most continuous in the Old Northwest (Table 1). The fort was one of several established just after the War of 1812, primarily to assert U.S. authority over the fur trade that had been long controlled by the British (Kellogg 1934). Fort Howard was erected in 1816–1817 on the low, swampy west bank of the Fox River very near the river's mouth at Green Bay (Fig. 1). Earlier the same site was occupied by the French fort, St. François (1717–1760), and the British post, Fort Edward Augustus (1761–1763). Sometime in early 1820, troops were removed from the fort and temporarily garrisoned at Camp Smith, about 6 km up the Fox River. But by late 1821, Fort Howard was again reoccupied. Weather observations began 8 August 1821 and continued until 30 June 1841 when the garrison was withdrawn to Florida for service in the Seminole War and later to Texas to serve in the war with Mexico. With the end of hostilities in 1848, troops returned to Fort Howard, and weather observations resumed for a brief period. Weather records are continuous from 1 October 1849 through 31 May 1852, just prior to final troop withdrawal and abandonment of the fort on 8 June 1852.[2]

The Fort Howard weather record is likely the only weather data available for the early to mid-nineteenth century in the Green Bay area. Between 1852 and the beginning of U.S. Weather Bureau observations in the city on 1 September 1886, only sketchy weather data exist for Green Bay. How reliable then is the Fort Howard weather record, and is it reasonable to

[2] In 1863, the federal government ordered the sale of the Fort Howard military reservation. Although the fort was subsequently razed, several of the buildings remained in use for many decades. Today, visitors to Green Bay's Heritage Hill State Park can view the original Fort Howard hospital (1834–1851) and reconstructed Surgeon's Quarters (1834–1851). The buildings are situated on a hillside overlooking the Fox River about 6 km upriver of the original site of the fort.

Table 1. Location and period of record of weather stations in the Old Northwest operated by the U.S. Army Medical Department

Army Post	*Present Name*	*Period of Record**
Fort Armstrong	Rock Island, Illinois	1824–1835
Fort Atkinson	Fort Atkinson, Iowa	1842–1846
Fort Brady	Sault Ste. Marie, Michigan	1823–1825, 1827–1828, 1830–1842+
Council Bluffs	Omaha, Nebraska	1820–1825
Fort Crawford	Prairie du Chien, Wisconsin	1822, 1824–1825, 1829–1845
Fort Dearborn	Chicago, Illinois	1832–1836
Fort Howard	Green Bay, Wisconsin	1821–1841, 1849–1852
Fort Mackinac	Mackinac Island, Michigan	1826, 1831–1836, 1842+
Fort Snelling	St. Paul, Minnesota	1819–1855
Fort Winnebago	Portage, Wisconsin	1829–1845

* Not necessarily complete years of data
Sources: Lawson, 1840, 1851; Miller, 1927

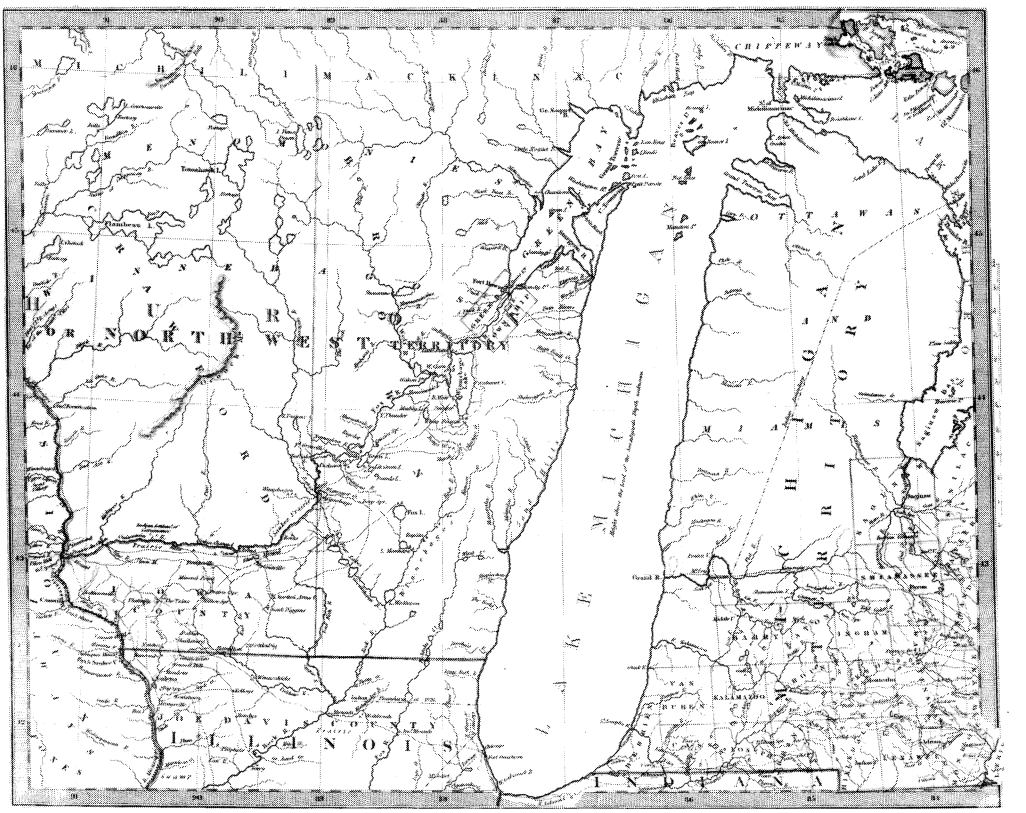

Fig. 1. Fort Howard was located near the mouth of the Fox River at Green Bay. When this map was published in 1833, army medical personnel at the fort had compiled almost 12 years of daily weather data. (North America Sheet V: The Northwest and Michigan Territories, 1833, Society for the Diffusion of Useful Knowledge. From the American Geographical Society Collection, University of Wisconsin-Milwaukee.)

draw comparisons between it and the modern climatic record of Green Bay?

This question is posed because of today's concern over the future course of climate and how variations in climate might affect society, a concern that has sent climatologists in search of an understanding of both how and why climate varies. Perhaps the most direct approach to determining this is to scrutinize closely the record of past climate because, after all, what has happened climatically can happen again. Unfortunately, in most places a reliable instrument-based record of past climate is limited to a little more than 100 years, and such record lengths simply may not encompass the full range of possible climatic variations. The lengthier and more detailed the view of the climatic past, the more data are available to aid in understanding how climate has varied and how it might vary in the future. The potential value, then, of the Fort Howard and other nineteenth-century weather records is evident.

Among the weather elements that constitute the Fort Howard weather record, temperature is the most convenient and perhaps most useful for drawing comparisons between the climate then and now. Except for the 1841–1849 hiatus when the fort was unoccupied, the pub-

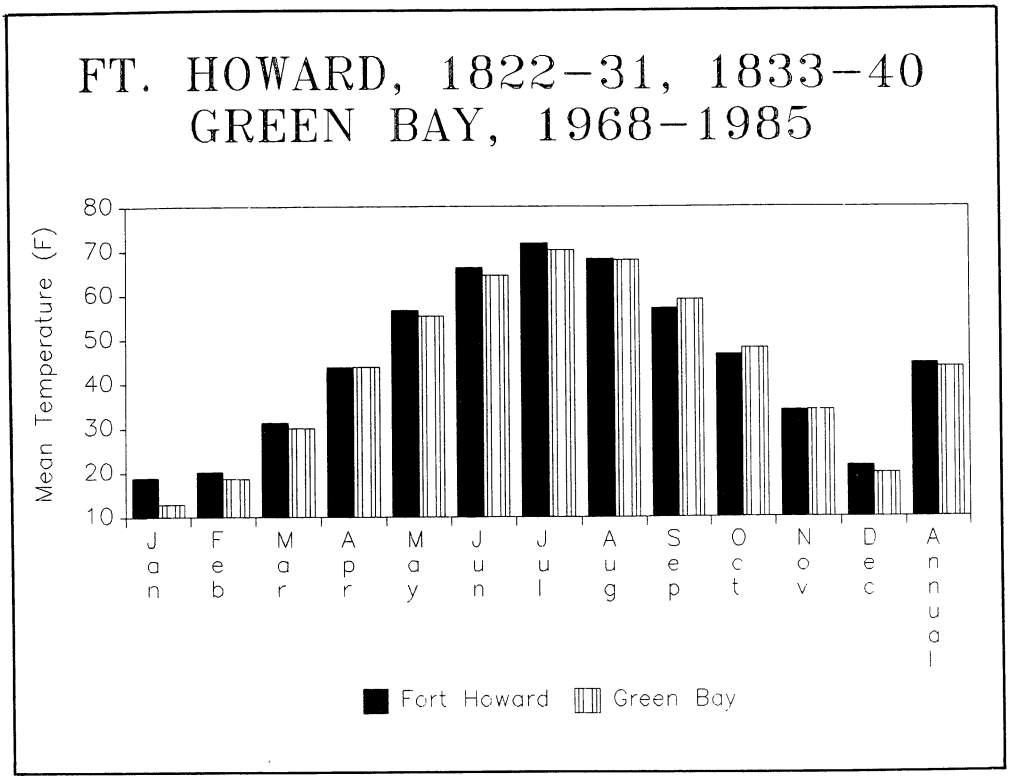

Fig. 2. Comparison of monthly and annual mean temperatures in °F at Fort Howard for 1822–1831 and 1833–1840, and Green Bay, Wisconsin for 1968–1985. Except for April and September through November, the recent period was cooler than the earlier period.

lished Fort Howard temperature record is remarkably complete through the cumulative 22 years and 7 months of weather observations. Only five days within this period (27–31 December 1832) are missing temperature data. Focusing on the first episode of weather observations and eliminating 1832 as well as the incomplete years of 1821 and 1841, there are 18 years (1822–1831 and 1833–1840) for which monthly and annual mean temperature data are available for comparison with the modern National Weather Service temperature record at Green Bay. That comparison is made for a recent 18-year period (1968–1985) in Figure 2 and suggests that, except for autumn (September, October, and November) and April, recent years have been cooler than the 1820s and 1830s. Particularly anomalous is January with a temperature difference of -5.9 F°. But just how realistic is this comparison? Several considerations bear on the integrity of the Fort Howard temperature record and hence, the validity of its comparison to modern climatic data. These considerations are (1) the accuracy, exposure, and location of the thermometer, (2) the method of computation of mean temperatures, and (3) the reliability of the weather observers.

Although we have no direct information on the thermometer at Fort Howard, we do have a description of the thermometer at Fort Snelling, a contemporary of Fort Howard, located near St. Paul, Minnesota. According to Ludlum (1968), William H. Keating, an explorer who

visited Fort Snelling in 1823, described the thermometer as "a glass tube attached to a brass plate, on which the graduation was marked" and which was made by "a Mr. Fisher of Philadelphia who sustains a high reputation as a manufacturer of that instrument." D. J. Warner, Curator of the History of Physical Sciences, The National Museum of American History, Smithsonian Institution, advises us (personal communication, 1986) that the Philadelphia city directories from 1793 to 1814 list Martin Fisher (1766–1826) as a thermometer maker. In 1816, he was joined by his son, Joseph Fisher (ca. 1795–1864), who continued the business until 1853. According to Warner, Fisher thermometers were "well regarded" although currently there are none in the museum's collection.

It is reasonable to assume that at least during the 1820s and 1830s, the Army Medical Department supplied all army posts with the same model thermometer, that is, a Fisher thermometer. *If* this assumption is correct and *if* Fisher's reputation as an instrument maker is justified, then we can also assume that Fort Howard's thermometer was accurate. Resting on such indirect evidence, however, this assumption is necessarily tentative.

Since August 1949 official National Weather Service instruments for Green Bay have been located at Austin Straubel Airport. (Previously, they were at downtown sites.) The airport is situated in a rural area of gently rolling terrain about 10 km southwest of the Fort Howard site. All other factors being equal, the airport's

Fig. 3. The waters of Green Bay likely moderated temperatures at Fort Howard on those days when regional winds were light or calm. But the Bay's moderating influence probably had little effect on monthly and annual mean temperatures. (Lithograph courtesy of the State Historical Society of Wisconsin.)

higher elevation (208 meters above mean sea level) versus that of Fort Howard (178 meters above mean sea level) coupled with the airport's greater distance from the moderating influence of the waters of Green Bay would favor a more continental climate at the airport (Fig. 3). (The more continental the climate, the greater is the contrast between summer and winter.) However, based on a comparison of contemporary temperature observations at the airport and at a site near the bay shore (the University of Wisconsin-Green Bay campus), the difference in continentality is insignificant in the time frame of months and years. On days when regional winds are light or calm, winter mornings typically are several degrees colder, and summer afternoons are a few degrees warmer at the airport. Nonetheless, there are only slight differences in monthly and annual mean temperatures.

Since national weather observation practices were standardized in 1873 (year of the founding of the International Meteorological Organization, predecessor of the World Meteorological Organization), monthly mean temperatures have been computed by averaging daily mean temperatures, which in turn are derived by simply taking one-half the sum of the 24-hour maximum temperature and minimum temperature. However, thermometers that register maximum and minimum temperatures and that can be reset once every 24 hours were not in use by the Army Medical Department's weather network (Forry 1842). At army posts, monthly mean temperatures were computed by averaging the mean temperatures obtained for each of the daily observations.

An estimate of the maximum error introduced by differences in the two averaging methods is based on a study by Baker (1975). Analyzing modern climatic data from St. Paul, Minnesota, Baker found that varying the time of day when the maximum/minimum thermometer is read and reset (that is, the observation hour) influences the daily mean temperature and hence, the monthly and annual mean temperatures as well. He noted variations of up to 1.7 F° in annual mean temperature and up to 2.3 F° in monthly mean temperature depending upon the specific hour of observation. Because observation hours at army posts were selected to catch the usual times of the day's lowest temperature (near sunrise) and highest temperature (early afternoon), it appears likely that the actual error arising from the army's averaging method would be less than that reported in Baker's study. Indeed, it is likely that the two averaging methods do not produce statistically significant differences in computations of monthly and annual mean temperatures. This same conclusion was also reached by Wahl (1968) and Thaler (1979) in their respective analyses of the Fort Winnebago (near Portage, Wisconsin) and West Point (New York) nineteenth-century temperature records.

Any question regarding the reliability of Fort Howard's weather observers is probably unwarranted. Although the army's weather observers were not professional meteorologists, the Medical Department supplied them with very detailed instructions on how to take and record weather observations. There were great demands on the time and energy of medical personnel at Fort Howard (and other posts as well) because they were the only physicians within hundreds of kilometers and they tended to the medical needs of the nearby civilian population as well as those of the garrison (Kellogg 1934). It is therefore all the more extraordinary that they carried out their weather observing duties with skill and dedication as is evident from even a cursory examination of the original journals (The National Archives 1952). Of the 10 weather observers who served at Fort Howard between 1822

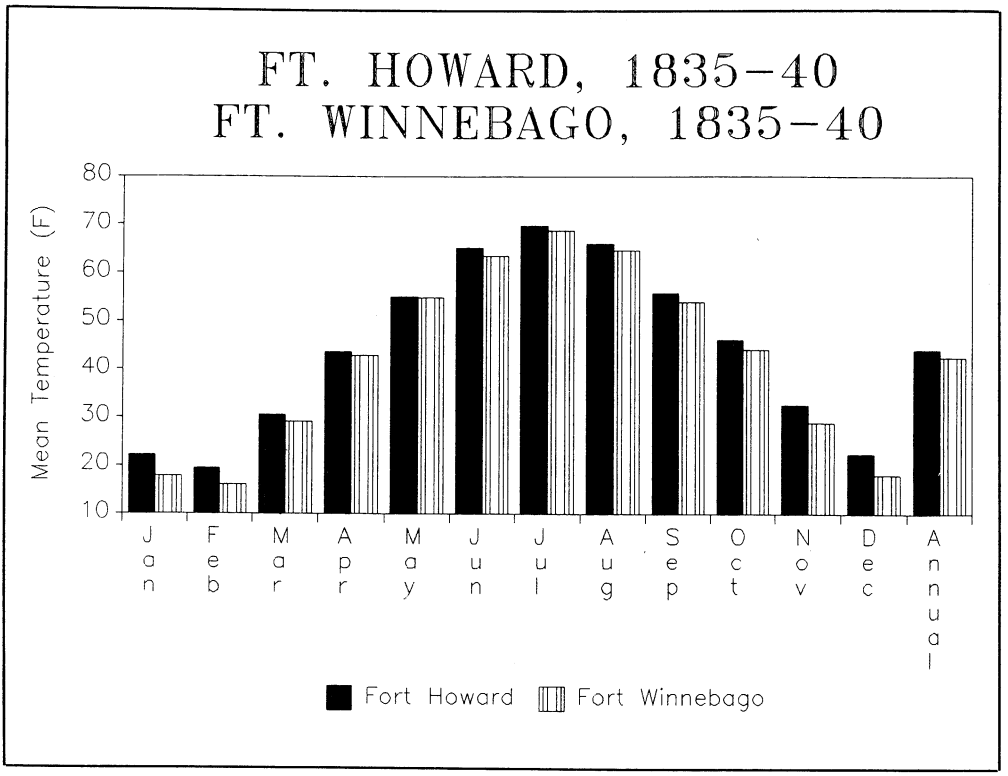

Fig. 4. Comparison of monthly and annual mean temperatures in °F for 1835–1840 at Fort Winnebago and Fort Howard. Even though Fort Winnebago was about 150 km southwest of Fort Howard, this comparison indicates that Fort Howard was warmer than Fort Winnebago—especially in winter.

and 1840, some of course were more diligent than others in their contribution to the "remarks" section of the journal. William Beaumont, M.D. who served from July 1826 to March 1828, was particularly conscientious and often made very detailed notes on weather and health.

Hence, it is reasonable to assume that the Fort Howard weather observers and thermometer were reliable and that the slightly less continentality of the Fort Howard site and the difference in averaging methods would contribute only minor errors to any comparison between Fort Howard and Green Bay temperature records. A much more serious question concerns the exposure of the Fort Howard thermometer.

Instrument Exposure Problem

Today, National Weather Service instruments are housed in a standard white louvered shelter that provides adequate ventilation and protects weather instruments from exposure to precipitation and direct sunlight. Widespread use of instrument shelters dates only to the 1870s even at official meterological stations.[3] Previously, thermometers were usually suspended unprotected just outside a window—and not always a north-facing window. An earlier custom of mounting a

[3] Middleton (1966) reports that in North America the earliest account of a sheltered thermometer was at the Toronto Magnetic and Meteorological Observatory in 1841. The thermometer was in a louvered shelter mounted on the Observatory's north wall.

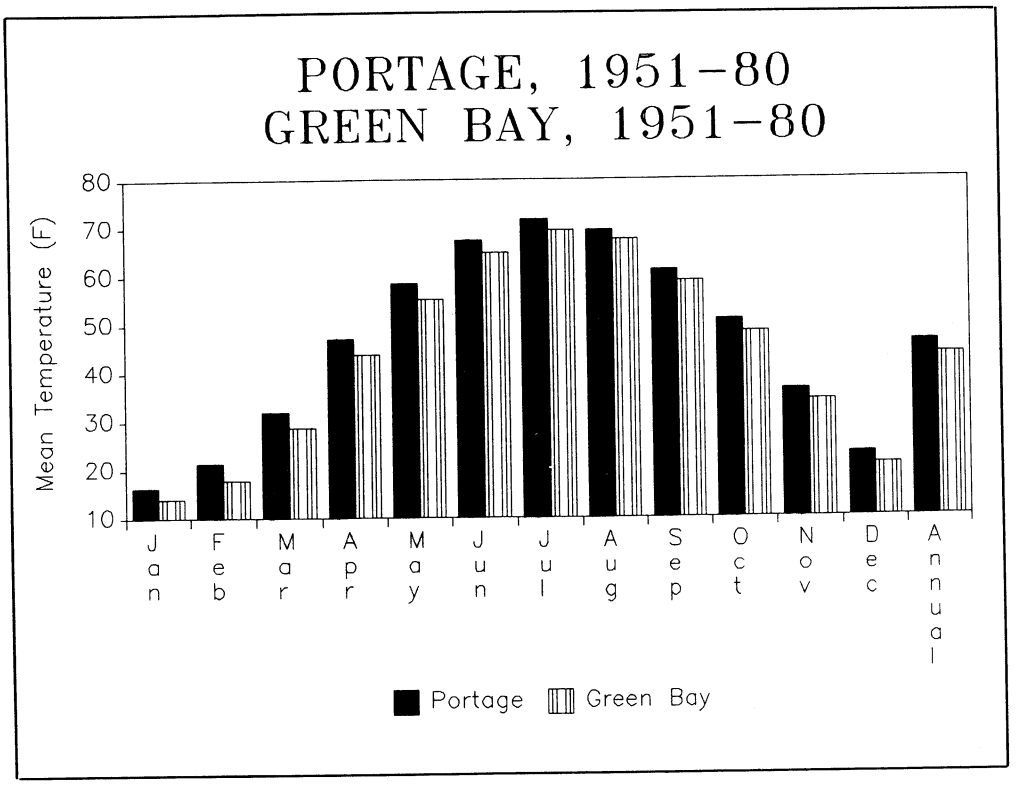

Fig. 5. Comparison of monthly and annual mean temperatures in °F for 1951–1980 at Portage and Green Bay. As expected, Green Bay is a colder locality than Portage.

thermometer indoors in an unheated room had been largely abandoned by the mid-1700s (Middleton 1966). Hence, based on the common practice of the day, chances are that the Fort Howard thermometer was outdoors and unsheltered (Miller 1931).

Studies of nineteenth-century weather records from Fort Winnebago, West Point, and Fort Snelling indicate that at times (diurnally and seasonally) thermometers were exposed to direct sunlight (Wahl 1968; Thaler 1979; Baker *et al.* 1985). This might well have been the case also at Fort Howard. Such exposure would introduce a major systematic error into the temperature record. Further complicating matters, however, is the possibility of undocumented changes in the exposure of the thermometer during the period of record.

Under ideal circumstances there would be other weather records from nearby localities covering the same period that could be used to corroborate the Fort Howard temperature record.[4] Unfortunately, the nearest contemporary army post keeping weather records was Fort Winnebago, located about 150 km to the southwest of Fort Howard. For six complete years of available records (1835–1840) that overlap, Fort Howard was considerably warmer than Fort Winnebago—especially in winter (Fig. 4). However, a

[4] Because variations in climate are geographically nonuniform in both direction and magnitude, the farther apart two weather stations are situated the less meaningful is a comparison of their records.

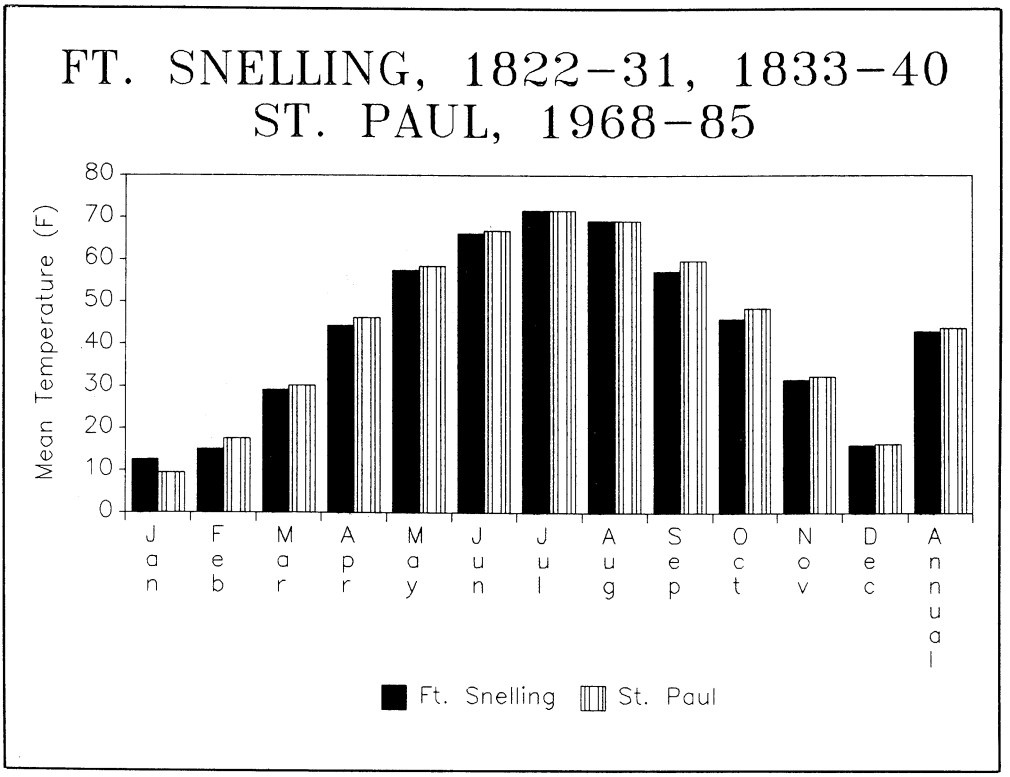

Fig. 6. Comparison of monthly and annual mean temperatures in °F at Fort Snelling for 1822–1831 and 1833–1840, and St. Paul, Minnesota for 1968–1985. Except for January and August, the recent period was warmer than the earlier period.

comparison of modern climatic data from Green Bay and Portage indicates that Fort Howard should have been colder than Fort Winnebago (Fig. 5).

Going even farther afield (about 390 km west of Fort Howard), the Fort Snelling temperature record also suggests that temperature readings at Fort Howard were anomalously high. Baker *et al.* (1985), having the benefit of overlapping temperature records from nearby localities, were able to correct the Fort Snelling record for instrument exposure problems, and they produced a reasonably homogeneous temperature series for St. Paul for 1820–1982. A comparison of monthly and annual mean temperatures at Fort Snelling for 1822–1831 and 1833–1840 with that at St. Paul for 1968–1985 is shown as Figure 6. January is the only month that is cooler in the modern record. A comparison of Figure 6 for St. Paul/Fort Snelling with Figure 2 for Green Bay/Fort Howard supports the conclusion that temperature reports for Fort Howard were too high.

Conclusion

Of the many factors that could impinge on the integrity of the Fort Howard temperature record, improper instrument exposure may be the most significant. In fact, improper instrument exposure may well invalidate any comparison between Fort Howard's temperature record and the modern temperature record at Green Bay. The value of the Fort Howard temperature record then is that it provides in-

sight on nineteenth-century weather observation practices and serves as a warning that early temperature records should be interpreted with caution. On the other hand, the Fort Howard weather logs include data other than temperature that may be useful in comparing the climate of then and now. Specifically, a comparison of the frequency of various weather types (e.g. snowfalls) might be a fruitful investigation.

Acknowledgments

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The Status of Canada Lynx in Wisconsin, 1865–1980

Richard P. Thiel

Abstract. *Eighty lynx* (Felis canadensis) *collected as museum specimens from Minnesota, Michigan, and Wisconsin were associated with periods of lynx invasions from Canada between 1865 and 1980. Historically, the lynx community in Wisconsin probably did not comprise a permanent self-sustaining population but rather was periodically replenished by lynx invasions from Canada. The continued lynx population probably did not persist in Wisconsin much beyond 1900. Factors such as lynx vulnerability, lack of adequate remote habitat, and Lake Superior (which prevents direct lynx movements to and from Canada) inhibit establishment of a Wisconsin lynx population.*

Canada lynx, an intermediate-sized feline, ranges throughout the boreal life zone of North America, and Wisconsin lies on the southern edge of its continental range. Lynx populations are irruptive and closely follow the population cycles of their primary prey, snowshoe hares *(Lepus americanus)* (Keith 1963). Individual survival and lynx population densities increase in response to periods of prey abundance. During and following prey population crashes, lynx densities decrease through emigration and lowered survival rate of individuals. Reliable accounts of lynx in the state are limited to records maintained by fur traders who document that some lynx were encountered in historic times (Jackson 1961). The persistence of reported sightings, tracks (Pils and Swanberg 1963; Pils and Bluett 1984; Schachte 1965; Records-Bureau of Endangered Resources, DNR), and even a few specimens (Doll et al. 1957; Jordahl 1956) have led some observers to conclude that a permanent lynx population currently exists in Wisconsin.

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The present study was undertaken to (1) determine the status of the lynx population in Wisconsin in relation to lynx status and distribution elsewhere in the upper Great Lakes Region and (2) bring together the scattered Wisconsin lynx records so that future researchers may have easier access to the available, albeit meager, data.

Methods

Wisconsin DNR carcass records were reviewed, and in the upper Great Lakes states (UGLS) of Michigan, Minnesota, and Wisconsin, museums were queried to obtain information on the date, location, sex, and method of take for each lynx specimen. Data on date and location of specimens were then compared with documented Canadian lynx irruptions (Elton and Nicholsen 1942; Keith 1963; Gunderson 1978; Mech 1980) to assess whether the occurrence of UGLS lynx specimens were associated with periods of mid-continental invasions. Regional literature, including scientific periodicals, local histories, newspapers, and the annual questionnaires (which solicit observations

of lynx in Wisconsin) filled out by bobcat hunters and trappers licensed by the DNR were also reviewed.

While sight and track reports of lynx by citizens are of questionable value, specimens offer bonafide proof of the occurrence of a species. Caution is warranted when utilizing museum specimens in attempting to determine species status because of sporadic or incomplete specimen sampling and because museum collections tend to underemphasize areas where a species commonly occurs. The assumption used to examine the available lynx data is that, in the absence of other explanations, lynx specimens associated with periodic Canadian irruptions indicate the presence of an established population, and conversely, specimen occurrences corresponding with periodic irruptions suggest the absence of a viable Wisconsin lynx population.

Results

UGLS Lynx Collections vs. Canadian irruptions. Figure 1 compares the occurrence of UGLS lynx specimens with peaks in lynx irruptions reported from Canada (Elton and Nicholson 1942; Keith 1963; Gunderson 1978; Mech 1980). In this study eighty lynx specimens—5 from Michigan, 16 from Wisconsin, and 59 from Minnesota, were located in museums. An additional 12 Wisconsin (Table 1) and 3 Michigan non-museum lynx carcass records were included in the analysis. Deposition of lynx specimens into museums has been sporadic; only 28 of the 95 known specimens were deposited in the 85 years prior to 1950.

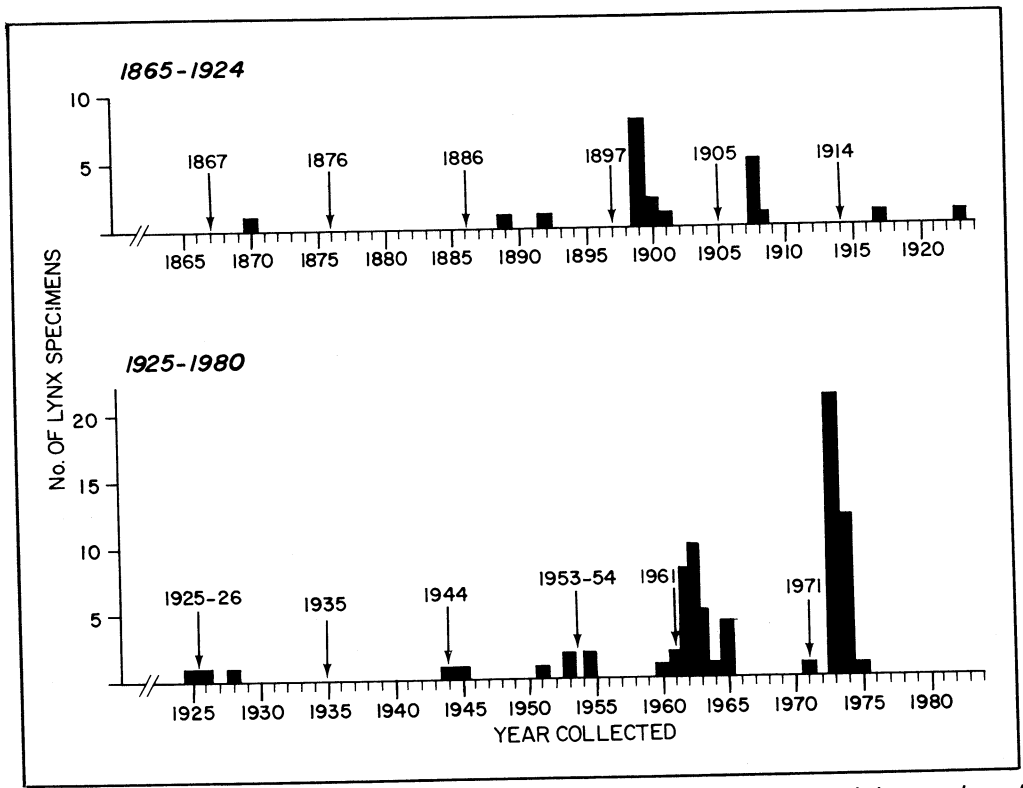

Fig. 1. Relationship between Canadian irruptions (arrows and dates), and the number of Upper Great Lakes states lynx specimens in museums and DNR carcass records.

Table 1. List of 13 non-museum lynx specimens handled by the Wisconsin DNR since 1960 (source, DNR Bureau of Endangered Resources).

Year	*Date of Capture*	*County*	*Sex*	*Method of Take*	*Method of Disposal*
1962	Nov.	Rusk	Unk.	Shot	Unk.
1963	Aug.	Douglas	Unk.	Shot	Unk.
1964	Nov. 22	Jackson	Unk.	Unk.	DNR-WI Rapids Office
1965?[1]	Unk.	Pierce	Unk.	Shot	Unk.
1965	Unk.	Green Lake	Unk.	Unk.	DNR McKenzie Env. Center, Poynette
1965	Unk.	Vernon	Unk.	Train-kill[2]	Unk.
1971	May	Trempealeau	F	Shot	Unk.
1972	May	Trempealeau	M	Shot	Unk.
1972	Sept. 17	Oneida	F	Car-kill	DNR Woodruff Office
1972	Oct.	Price	Unk.	Trapped	Unk.
1972	Fall	Lincoln	Unk.	Shot	DNR Rhinelander HQ
1973	Jan.	Iron	Unk.	Trapped	Released
1974	Nov. 20	Marinette	Unk.	Shot	DNR Marinette[3]

[1] Record unclear as to year.

[2] A lynx was killed by a train near Viroqua in 1965; however, another record, based on recollections, lists one "shot" in Vernon County in approximately 1968. The two records probably refer to the same event. The 1965 account appears to be more reliable.

[3] The skeleton of the stuffed skin displayed at DNR Marinette office is housed and catalogued at UW-Marinette Extension campus.

Patterns of lynx irruptions from Canada and the increased collection of UGLS lynx specimens correspond. With the exception of 2 specimens (1889 and 1892), all UGLS lynx specimens have been associated with Canadian irruptions. The mean lapse between Canadian irruptions was 9.5 years while the mean lapse between collection of Wisconsin lynx specimens was 9.7 years. Collection of UGLS lynx specimens lagged 0 to 3 years (1.5 average) behind Canadian irruption peaks.

Lynx Behavior. Fearless behavior toward humans is sometimes displayed by lynx during invasions (Adams 1963; Mech 1973; Gunderson 1978). This behavior has also been observed in Wisconsin and promotes the association of lynx presence in the state with periods of invasions. In July 1926, a lynx was shot while sitting on the top of a street lamp in downtown Shell Lake (Washburn Co.) (Stouffer 1961), and in the fall of 1972, one was shot after reportedly attacking a man who was working in his garden within the City of Tomahawk (Lincoln Co.) (A. Loomans pers. comm.). The relative "boldness" of lynx during population irruptions increases their vulnerability.

Recent Lynx Observations in Wisconsin. Since 1976 Wisconsin DNR annual bobcat hunter/trapper questionnaires have solicited observations on lynx. A mean of 7% of respondents reported observing lynx tracks between 1976 and 1984 (W. Creed and C. Pils pers. comm.), ranging from 2% (1984) to 14% (1976). Wisconsin's northwestern counties have the highest percent of lynx observations (Fig. 2) with Douglas County, which lies adjacent to Minnesota, having the greatest number of lynx observations. This observation pattern is expected when lynx movement from Canada occurs.

Sex Ratios. The sex ratio of 11 Wiscon-

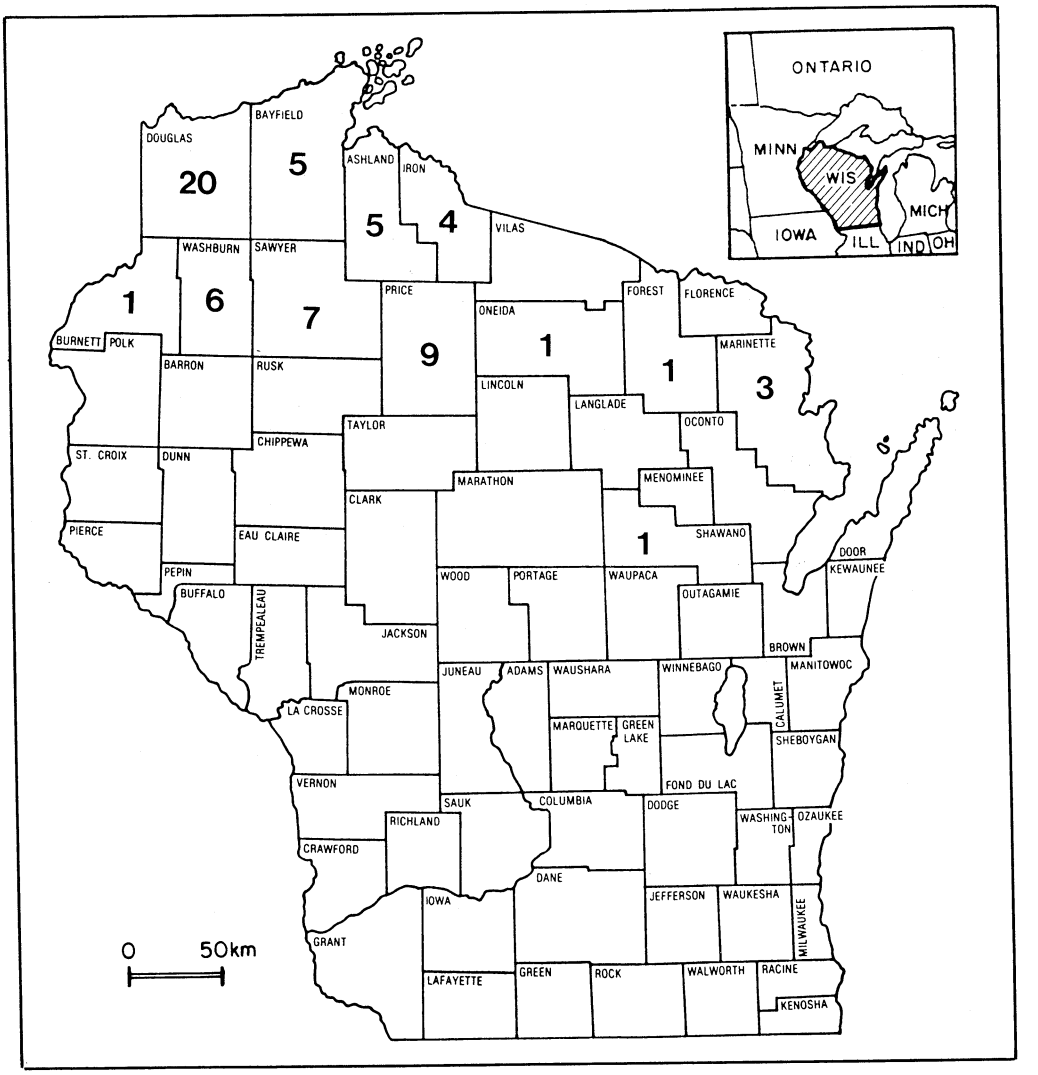

Fig. 2. Number of lynx reports, by county, obtained from annual DNR bobcat harvest questionnaires, 1976–1984.

sin lynx for which sex was recorded was 3 males and 8 females. Of these, the sex ratio of 3 lynx taken in the southern half of the state was 2:1 while the ratio of 8 taken in the northern portion was 1:7. Mech (1980) observed an even sex ratio among lynx during the 1972–73 peak in lynx numbers in northeastern Minnesota and a prevalence of female lynx as numbers declined in subsequent years. The same phenomena was noted in Manitoba during the 1971–73 irruption period (Koonz 1976).

Cause of Mortality and susceptibility. Of 18 Wisconsin lynx for which cause of death was known 13 were shot, 3 were trapped, 1 was struck by a vehicle, and 1 was struck by a train. Large numbers of lynx were trapped or shot in North Dakota following the 1961 irruption (Adams 1963), and Henderson (1978) and Mech (1980) noted that lynx were shot,

trapped, and hit by cars in Minnesota during 1971–75.

Discussion

Lynx Population in Wisconsin

Comparisons of dates of known lynx mortalities in the UGLS (Fig. 1) and in Wisconsin (Table 1) with Canadian irruption patterns (Fig. 1) indicate that lynx in Wisconsin and the UGLS are associated with periodic invasions of lynx from Canada. The behavior of lynx within Wisconsin and elsewhere in the UGLS suggests an origin from areas of Canada where there is little or no contact with humans.

Lag time variations occur in Wisconsin and elsewhere south of Canada and are a function of distances from population centers, the amplitude of the irruption period, as well as the relative size of the Canadian population of lynx during irruptions. Peak numbers of lynx in Minnesota and North Dakota occurred in 1962–63 while peaks in Montana (Gunderson 1978) and Wisconsin occurred in 1963–64 (this study) following the massive 1961 Canadian irruption. The effect of distance on lag time was illustrated by comparing the season where lynx carcass retrievals peaked in the northern and southern portions of Wisconsin. Peak lynx occurrences in southern Wisconsin (spring) lagged one full season behind peak northern occurrences (winter). Four lynx recovered in southern Wisconsin (Jefferson Co. 1870; La Crosse Co. 1917; Green Lake Co. 1965; Vernon Co. 1965) lagged three to four years behind the Canadian irruptions.

Lynx that may be present in Wisconsin between irruptive peaks probably represent individuals that failed to return to Canada following periodic population surges. If a viable lynx population existed in Wisconsin, greater numbers of lynx would be taken incidental to other hunting and trapping efforts, at least during irruptions, and some lynx would be expected to be taken between years of irruptive peaks (Bailey et al. 1986; Koonz 1976; Mech 1980). This is not indicated by either the museum specimens or DNR (carcass) records.

A continuous lynx population probably has not existed in Wisconsin since about 1900. Historical records (Jackson 1961) suggest that lynx populations in Wisconsin probably fluctuated dramatically and thus probably have been dependent upon periodic influxes from Canadian population centers for rejuvenation. The importance of these periodic irruptions to lynx viability in Wisconsin was probably similar to the ebbing and waning of turkey (Schorger 1942) and quail (Errington 1967) population distribution in Wisconsin during pre-settlement times. Lynx populations may never have been totally self-supportive since Wisconsin lies at the southern edge of the species' continental range.

Prospects of Lynx Recovery Within Wisconsin. Lynx are not a viable species within Wisconsin. No documentation of breeding has been found historically or within recent times in the state. Individual lynx are periodically present in Wisconsin, however, especially following Canadian irruptions. Conceivably the establishment of a resident lynx population within Wisconsin could occur if some individuals successfully colonized areas of the state following an invasion period. Since 1900, however, there have been eight Canadian irruptions of various magnitudes (Fig. 1), but lynx have failed to become established in Wisconsin. Apparently, insufficient numbers of lynx enter the state to establish a viable population or conditions in the state are not conducive to maintaining a permanent, resident population.

Lake Superior serves as a barrier against southward movements of lynx in-

to Wisconsin and upper peninsula Michigan. Gunderson (1978) noted that lynx occurrences in Wisconsin and Michigan were substantially fewer than from Minnesota and North Dakota during the 1961 irruption and suggested that the Great Lakes "impeded the southward movement" of lynx. Likewise Mech (1973) and Henderson (1978) noted unusual numbers of lynx west from the tip of Lake Superior as they moved south out of Canada.

The possibility of establishing a lynx population in Wisconsin might be enhanced through proliferation of a Minnesota lynx population that is speculated to exist (Henderson 1978; Mech pers. comm.; Boggess pers. comm.). About 650 lynx were harvested in Minnesota between 1972 and 1974. By 1975, however, none were harvested (Mech 1980). Lynx were classified as a "protected" species in Minnesota in 1976 with a limited season established by the state. Annual seasons, not exceeding two months, were held from 1976 through 1983, and the season was closed entirely in 1984 and 1985. It is uncertain whether a resident lynx population will expand in Minnesota under current management strategies.

Mech (1980) postulated that the rapid disappearance of lynx from northern Minnesota in 1974–75 was due to human-caused mortality and possibly the return of lynx to Canada. Mech (1977) documented the latter phenomenon with a female captured in Minnesota in 1974 that was trapped 480 km north in Ontario in 1977. Although return movements of lynx may diminish the chances of establishing a population in Wisconsin, it is also probable that Lake Superior acts as a barrier to northward movements of lynx once they reach Wisconsin. This may explain the presence of a few lynx records from southern Wisconsin up to four years after Canadian irruptions.

Large numbers of lynx are killed incidental to other types of hunting and trapping in the UGLS following invasions. Lynx may be overexploited in and around regions accessible to humans (Bailey, et al. 1986), and they appear to be more susceptible to hunting and trapping than wolves *(Canis lupus).* Accessibility facilitates increases in human activity, which is known to limit wolf survival (Thiel 1985). Lynx are not prevalent in northern Minnesota where the largest viable wolf population in the conterminous U.S. exists. It seems that human activity has more of an impact on lynx than on wolves. Given present conditions it is doubtful that lynx could become established in Wisconsin, where wolves are highly endangered, partly because of the greater access and higher levels of human activity.

Recommendations

Lynx should remain listed as an endangered species in Wisconsin, and wildlife officials should be alert for signs of lynx proliferation following Canadian irruptions. It is recommended that the DNR (1) adopt a policy to collect information on the date, location, age, sex, reproductive status, and method of kill for all future lynx carcasses recovered in Wisconsin, (2) require that all future lynx carcasses be deposited in recognized museum collections where retention of pertinent data is assured, and (3) incorporate lynx identification and education efforts as a part of its youth hunting and trapping programs.

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The Flora of Wisconsin
Preliminary Report No. 69
Euphorbiaceae—The Spurge Family

James W. Richardson, Derek Burch, and Theodore S. Cochrane

From the diminutive seaside spurge of the Great Lakes strand to the gorgeous Christmas poinsettia of Mexico and the giant rubber trees (genus *Hevea*) of Amazonia, the Euphorbiaceae is one of the largest families of flowering plants. Its 300 genera and at least 7,000 species are ecologically diverse and widely distributed, especially in the drier tropics. Most are said to be poisonous, a few are troublesome weeds, and a wide variety are cultivated as ornamentals *(Acalypha, Euphorbia, Poinsettia, Ricinus, Codiaeum).* A few others are valued for their economically important products, including food *(Manihot utilissima),* natural rubber (*Hevea, Manihot* spp.), oils *(Ricinus, Croton, Aleurites),* dyes *(Sapium, Mallotus),* and drugs *(Jatropha curcas, Croton tiglium).*

The Euphorbiaceae are clearly a specialized family, as shown by the advanced morphology of its greatly reduced flowers, especially the peculiar flower-like inflorescence (cyathium) of *Euphorbia* [sens. lat.], and the complex secretory tissues, which besides latex (often white) produce a great variety of compounds. Of its two major floral patterns, the "Euphorbia-type" is exhibited by the tribe Euphorbieae and the genus *Dalechampia,* and the "non-Euphorbia-type" by the remaining genera. In the latter, the perianth is 5-merous, except where one or both of the whorls are absent, and the staminate flower generally has 5 or 10 (or up to 400 or more) free or variously united stamens. A lobed disk is commonly present, at least in the pistillate flowers.

The basic unit of the "Euphorbia-type" inflorescence is a complex, highly specialized cymose inflorescence called the *cyathium* (Fig. 1), containing a solitary pistillate flower surrounded by few to several groups (cymules) of staminate flowers. The pistillate flower consists of only a single naked pedicellate pistil, each staminate flower of only a single stamen jointed to the pedicel (Fig. 1). Each small aggregation of these tiny naked flowers is surrounded by a hypanthium-like involucre, the individual bracts of which are discernible as lobes at the rim. The cup-shaped or urn-shaped involucre usually bears 1 to 5 (or more) glands on the top between the lobes and sometimes also horn-like or petaloid appendages. That the cyathium as a whole simulates a single bisexual flower (pseudanthium) is enhanced by the central stipitate ovary (Fig. 1). In fact, the compound inflorescence of irregularly clustered cyathia at the summit of the stem may itself mimic a giant flower, as in *Poinsettia.*

The fruit is customarily referred to as a capsule, although strictly speaking it is a capsular schizocarp. When ripe, the dorsal walls of the locules separate septicidally from the persistent central axis (colu-

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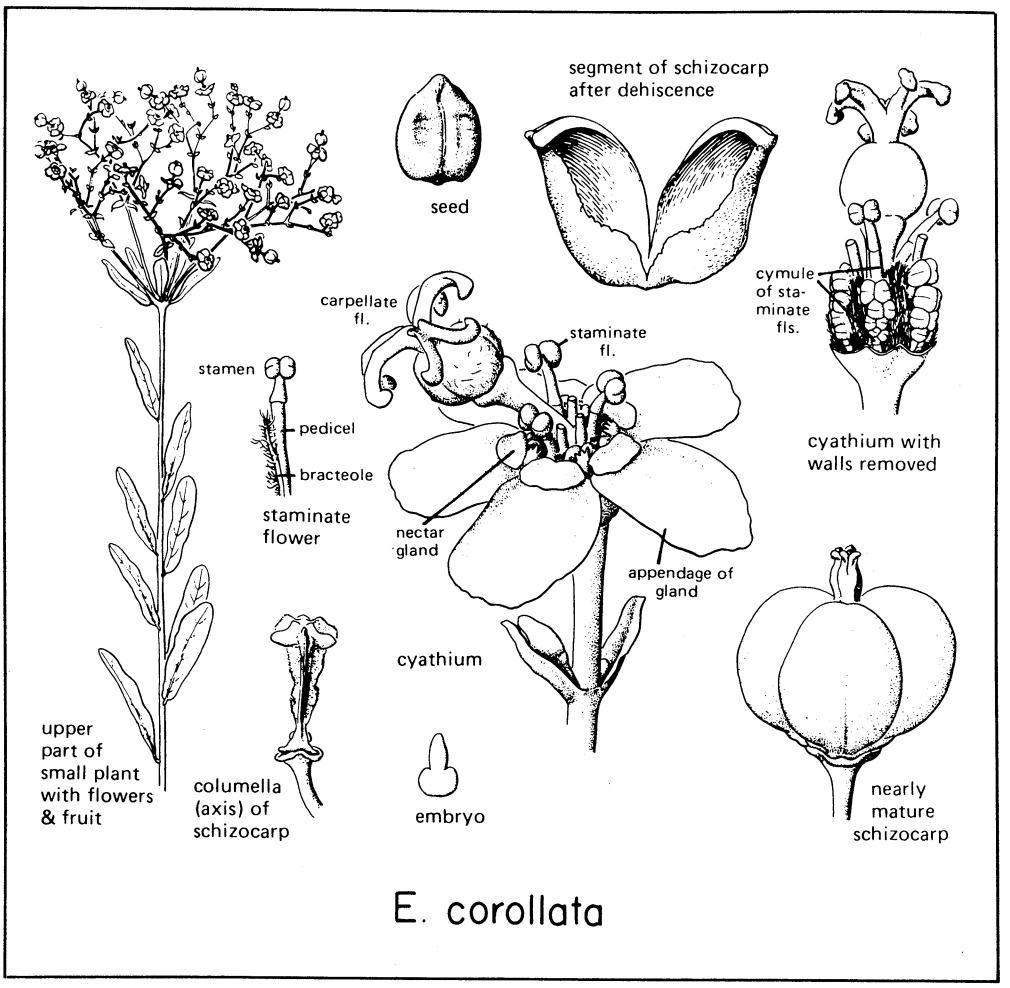


Fig. 1. Euphorbia corollata. *Habit of plant and parts of the cyathium during staminate and fruiting stages. The "Euphorbia-type" inflorescence or cyathium consists of many reduced staminate flowers and a solitary pistillate flower surrounded by a hypanthium-like involucre. (From Wood, 1974.)*

mella) into 1-seeded mericarps, which eventually liberate their seeds through a ventral opening of the locules.

During development and maturation a cyathium passes through five basic stages, which are apparently quite similar among different species. These stages have been described and illustrated by Ehrenfeld (1976).

The Linnaean *Euphorbia* is probably one of the most broadly inclusive genera that still has wide currency in the modern literature. The problem of whether to treat the genus in its entirety or to split it into several genera is one that will undoubtedly be discussed for years to come. In the major early surveys (Boissier 1862; Pax & Hoffmann 1931) *Euphorbia* was retained intact. Subsequent workers have attacked the problem in several ways, either 1) combining all proposed generic segregates into the single large genus *Euphorbia* (Gleason & Cronquist 1963; Voss 1985); 2) reducing such segregates to

sections or subgenera of *Euphorbia* (Norton 1900; Wheeler 1941; Fernald 1950; Gleason 1952; Richardson 1968; Walters & Tutin 1968); or 3) recognizing these as separate genera (Rydberg 1932; Small 1933; Croizat 1936; Dressler 1961; Burch 1966b). In the present treatment we follow the latter authors and regard certain natural, albeit weakly defined, segregates as worthy of generic rank.

A recent paper by Webster (1967) is perhaps the best single reference to consult for a more detailed account of the systematics and phylogeny of the Euphorbiaceae.

The present paper revises Fassett's (1933) treatment of the Wisconsin Euphorbiaceae. It is based on specimens deposited in the herbaria of the University of Wisconsin System, namely Madison (WIS), Milwaukee (UWM), Oshkosh (OSH), La Crosse (UWL), River Falls (RIVE), Rock County Center-Janesville (UWJ), Green Bay (UWGB), Platteville, and Eau Claire, as well as Milwaukee Public Museum (MIL), University of Minnesota (MIN), University of Iowa (IA), and the private herbarium of Katherine D. Rill (Oshkosh, Wisconsin). Thanks are due to the curators of the above herbaria for loans of specimens.

Dots on the maps represent specific locations where specimens have been collected; triangles indicate county records when specific locations are not known. The numbers within each map inset in the lower left-hand corner show the amount of flowering and fruiting noted on all the specimens observed and indicate the months when the species may be expected to flower or fruit in Wisconsin. Specimens with vegetative growth only or buds or dispersed fruits are not included. For introduced species and obvious adventives the year of earliest collection within a county is also recorded.

EUPHORBIACEAE[1] Juss.
Spurge Family

Monoecious or rarely dioecious herbs, annual (but occasionally perennating) or perennial, some with milky latex in all parts. Leaves simple, alternate or sometimes opposite, usually with stipules. Inflorescences spicate, unisexual or bisexual, or with very reduced flowers collected inside a small cupulate perianth-like involucre to form a pseudanthium (cyathium). Flowers always unisexual, much reduced, the calyx or corolla minute or either or both lacking. Staminate flowers usually several, with 1-many stamens. Pistillate flower solitary; ovary superior, 3 (rarely 1-2)-locular, each locule with a separate style and 1 ovule. Fruit a capsule, typically dehiscing elastically into 3 (very rarely 2) 1-seeded segments (mericarps). Seeds often carunculate.

Perennial species flower in late spring or summer. Most of the annuals become fertile while very young and have all stages of flower and fruit present after a few weeks of growth.

A vast and diverse, mostly tropical family, represented in Wisconsin by a miscellaneous assemblage of 22 species in 5 genera (only 3 if *Euphorbia* is viewed as an all-inclusive genus). Many of the species are decidedly weedy and are common in disturbed habitats. *Phyllanthus tenellus* Roxb., an Old World species adventive in the southeastern U.S., was collected "among cult. garden flrs." at Madison in 1983 (*Bremer 21,* WIS). It is a glabrous annual that lacks latex and has tiny pendulous flowers solitary in the axils of alternate entire leaves. It is not, as yet, an element in our flora.

[1] Descriptions and keys apply to Wisconsin material only.

KEY TO GENERA

A. Flowers clearly unisexual, variously arranged but not collected into cyathia; staminate or pistillate flowers or both with a perianth; juice watery.
  B. Plants pubescent with at least some stellate trichomes; staminate flowers mostly with biseriate perianth; pistillate flowers without a leafy bract (Subfam. CROTONOIDEAE Pax). . . . . 1. *CROTON.*
  BB. Plants sparsely pubescent with simple hairs; staminate flowers apetalous; pistillate flowers encircled by a prominent leafy bract (Subfam. ACALYPHOIDEAE Ascherson). . . . . 2. *ACALYPHA.*
AA. Flowers (one central pistillate and few to many staminate) aggregated within a cupulate involucre (cyathium) simulating a single flower; flowers without a perianth; juice milky (Subfam. EUPHORBIOIDEAE).
  C. Glands of cyathium 1 (rarely 2 or 3), without appendages; leaf bases essentially symmetrical; cyathia irregularly clustered at summit of erect stem and ascending branches; annuals. . . . . 3. *POINSETTIA.*
  CC. Glands of cyathium consistently 4 or 5, exappendiculate or with petaloid or horn-like appendages; leaf bases and cyathia various; annuals or perennials.
    D. Leaves all opposite, with distinctly inequilateral bases; cyathia solitary in upper axils or in axillary glomerules (not in "umbels"); annuals with stems low, prostrate or ascending (rarely suberect or tips erect); stipules well developed. . . . . 4. *CHAMAESYCE.*
    DD. Leaves alternate at least below, with ± equilateral bases; cyathia in a terminal umbelliform cyme; annuals or perennials with stems tall and erect (rarely ascending); stipules none . . . . . 5. *EUPHORBIA.*

1. **CROTON** L. Croton

Monoecious annual (ours) *herbs* without milky latex, variously pubescent with at least some stellate trichomes. *Leaves* alternate (appearing opposite just below the inflorescence), stipulate, with an unlobed blade. *Inflorescences* dichasial or subcapitate, terminal or axillary, bisexual, mostly with a few ♀ flowers below a short spikelike raceme of ♂ flowers. Disk (of lobes or separate glands) usually present in ♂ or ♀ flowers or both. *Staminate flowers* with biseriate perianth (petals sometimes rudimentary or none); stamens equal in number to three times as many as the small or rudimentary corolla lobes. *Pistillate flowers* gamosepalous (calyx 5- to 9-lobed), apetalous; ovary (2- or) 3-celled, each locule with 1 ovule; styles equal in number to carpels, bifid or 2 or 3 times dichotomous. *Capsule* with 1 seed per carpel (or in *C. monanthogynus* fewer-celled and 1-seeded by abortion), usually pubescent. *Seeds* smooth, usually glossy, carunculate.

A large but natural genus of 600 to 800 species of herbs, shrubs, and trees, two-thirds of which are South and Central American or West Indian; represented in southern Wisconsin only by three widespread taprooted annual weeds. A fourth, entire-leaved southeastern U.S. species, with 3 styles, erect capsules, and plumply lenticular seeds about 4 mm broad, *C. capitatus* Michx., has been collected at Poynette as an accidental introduction among sweet potato vines shipped in from Tennessee (*Kelton 3,* ca. 1 Sep 1955 [fl, fr], WIS).

KEY TO SPECIES

A. Plants dioecious; staminate flower apetalous; styles 3, repeatedly dichotomous; very rare adventive. . . . . 1. *C. TEXENSIS.*

AA. Plants monoecious; staminate flowers with small petals; styles 2 or 3, deeply bifid.

B. Leaves crenate-serrate; leaf blade with 1 or 2 minute glands on lower surface near junction with petiole; styles 3 (stigmas 6 per flower); mature capsule 3-seeded; uncommon in disturbed sand prairies. . . . 2. *C. GLANDULOSUS.*

BB. Leaves entire; leaf blade without glands; styles 2 (stigmas 4 per flower); mature capsule 1-seeded; rare adventive. . . . . 3. *C. MONANTHOGYNUS.*

1. CROTON TEXENSIS (Kl.) Muell.-Arg.
Skunkweed, Texas croton Map 1.

Dioecious, canescent-stellate, dichotomously branched *HERB* 0.3–15 (usually 2–8) dm tall. LEAVES linear-oblong to oblong-lanceolate, 2–8 cm long, entire. STAMINATE PLANTS smaller and with narrower leaves than pistillate ones, usually with numerous flowers: *sepals 5, petals 0,* and stamens 8–12. PISTILLATE PLANTS with fewer flowers, 1–5 in each short raceme: *petals 0, styles 3, each divided nearly to the base into 4 or more branches.* Mature CAPSULES 4–6 mm long, 3-carpellate, stellate-tomentose.

Dry prairies and waste areas in sandy loam from Ala. to Tex., Ariz. and nw. Mex., north to Wyo., S.D. and Ill., occasionally adventive as far east as N. Engl., in Wisconsin still known only from a single old collection (plant staminate; undoubtedly a waif): Milwaukee Co.: railroad tracks by the Kinnickinnic River, Milwaukee (*Bennetts s.n.,* 4 Sep 1899 [fl], MIL).

2. CROTON GLANDULOSUS L. var. SEPTENTRIONALIS Muell.-Arg.
Sand croton Map 2, Fig. 2.

Coarsely stellate-pubescent annual HERBS 0.5–5 dm tall, usually branched. LEAVES petiolate; stipules minute; *blades* 3–8 cm long, oblong to narrowly ovate or lanceolate, *serrate, with 2 subsessile whitish glands on the abaxial surface near the junction with the petiole.* INFLORESCENCE terminal, often overtopped by 2–4 lateral branches, usually with 3–5 subsessile ♀ flowers at the base of a short (ca. 10 mm long) spike of ♂ flowers. STAMINATE FLOWERS 4- or 5-merous, the petals white, small but sometimes conspicuous, the stamens 7–9 (or more?). *PISTILLATE FLOWERS with 5* sepals and *5 minute petals,* the ovary 3-carpellate, the *styles 3, bifid* almost to base. CAPSULE subglobose,

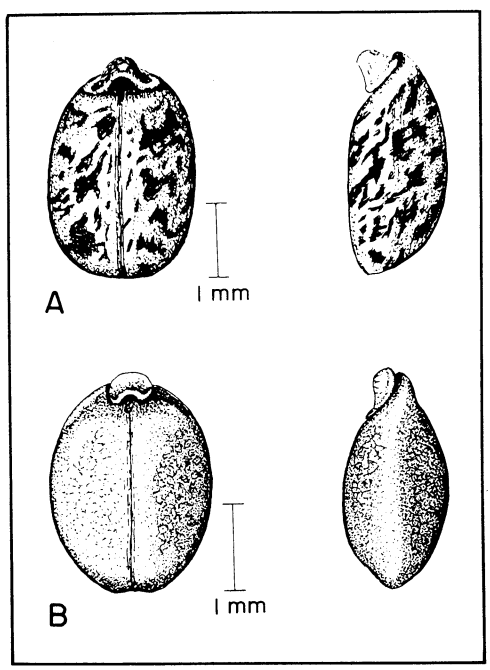


Fig. 2. Seeds of Wisconsin Crotons: A) Croton glandulosus; *B)* C. monanthogynus. *Adaxial (ventral or raphal) view (left) and lateral view with raphe on the left and micropyle up (right).*

4–5 mm long. SEEDS broadly oblong, 3–3.5 mm long, grayish-tan mottled with black, the surface minutely reticulate and somewhat shiny; caruncle well developed.

Widespread in eastern N. Am. (N.J. to Wis., Ia. and Kans., south to Fla., w. Tex., and n. Mex.), a native of dry open sandy woods, prairies, and plains, and adventive in cultivated fields and roadsides, in Wisconsin essentially confined to dry sandy plains on old terraces of the Mississippi and Wisconsin rivers, occurring in sunny open habitats, especially in disturbed sand prairies (with *Bouteloua hirsuta*), margins of blowouts (with *Euphorbia corollata* and *Hudsonia tomentosa*), and sand pits, such as at Bagley, Grant Co., with *Polanisia dodecandra, Cenchrus longispinus,* and *Triplasis purpurea* (*Nee 5432,* WIS), occasionally on roadsides or in fallow fields, such as near Spring Green, Sauk Co., with *Cycloloma atriplicifolia, Froelichia floridana, Mollugo verticillata, Oenothera cleelandii,* and weedy grasses, including *Setaria viridis, Digitaria ischaemum,* and *Panicum virgatum* (*Cochrane 11473,* NY, WIS). Scanty herbarium material and field experience indicate that *C. glandulosus* is rare, but it can sometimes be locally abundant. It is generally thought to be native south of Wisconsin, and it was not collected in the southwestern part of our state until 1935 (Columbia Co.). The isolated Sheboygan collections are from waste places in the city (*Goessl s.n.* in 1904 and 1941, both WIS). Flowering 17 Jun to 11 Sep; fruiting 18 Jul to 7 Oct.

This species is easily recognized by the sharply dentate leaves, glands at the base of the leaf blade, and staminate flowers with only 7–9 stamens. It exhibits much variability throughout its range, and several intergrading varieties have been distinguished on the basis of hair length and density, basal gland thickness, and seed shape and size. Wisconsin specimens almost invariably have relatively dense pubescence and hence belong to var. *septentrionalis* Muell.-Arg.

3. CROTON MONANTHOGYNUS Michx.
Prairie-tea Map 1, Fig. 2.

Annual HERBS 1–4 dm tall, finely and densely whitish-stellate or the stems minutely rusty-glandular; stems umbellately 3- to 4-forked below, repeatedly 2- to 3-forked or alternately branched above. LEAVES petiolate, the blades oblong to ovate, 1–3 cm long; stipules minute. *RACEME* terminal, overtopped by one or rarely more laterals, *usually with a solitary ♀ flower on a short recurved pedicel* at the base of a short erect spike of ♂ flowers. STAMINATE FLOWERS with 3–5 sepals, 3–5 petals, and 3–8 stamens. PISTILLATE FLOWERS with 5 sepals and 0 petals; *ovary 2-celled,* one normal and 1-ovulate, the other usually aborting; *styles 2, each deeply bifid. CAPSULE* ovoid, 4–5 mm long, *1-seeded.* SEEDS plumply lenticular, ca. 3 mm long, dull, slightly roughened, brown, with a small caruncle.

Common in dry calcareous soil from Fla. to Tex., north to Md., O., Ill., Ia., and Kans. (also ne. Mexico), occasionally adventive farther north, apparently adventive in Wisconsin: Sheboygan Co.: coal yards, Sheboygan (*Goessl s.n.,* Jul 1903 [fl], WIS); Grant Co.: railroad, Muscoda (*Davis s.n.,* 11 Jul 1934 [fr], WIS); sand prairies between railroad and Hwy. 137, W of Muscoda (*Iltis 28,435,* 9 Jul 1978 [fl], WIS).

Specimens from Grant County are not typical *C. monanthogynus.* From that species they differ in stamen number (8–12) and stigma number (6, the 3 styles deeply bifid) and in their more fertile capsules, which are 3-carpellate and 3-seeded, and larger seeds (3–4 mm long), which are uniformly shiny brown, only slightly flattened, and prominently carunculate. In typical *C. monanthogynus* the stamens

are normally 3 to 8, carpels 2, each with a deeply bifid style, capsule 1- (rarely 2-) seeded, and seeds 2.8–3.1 mm long, plumply lenticular, mottled dark brown, and with a small caruncle. These Wisconsin specimens exhibit many of the same characters found in *C. capitatus* var. *lindheimeri* (Engelm. & Gray) Muell.-Arg., a variety abundant in the se. U.S. That taxon, however, has 6–10 calyx lobes, while typical *C. monanthogynus* (and the Grant Co. material) has 5 calyx lobes and much larger seeds. Additional collections are needed to more accurately assess this situation.

2. **ACALYPHA** L. Acalypha

[Miller, L. W. 1964. A taxonomic study of the species of *Acalypha* in the United States. Ph.D. Dissertation, Purdue Univ. 198 pp.]

Annual (ours) *herbs* with clear (not milky) latex, sparingly to much-branched. *Leaves* alternate, crenate to serrate or entire, with 2 prominent lateral veins from the base. *Inflorescences* spicate; flowers unisexual, the *staminate* very small, apetalous, clustered in small axillary spikes borne on a short peduncle, the *pistillate* 1–3 at base of same spike or occasionally in separate ones, surrounded by a variously lobed foliaceous bract. Disk none. Ovary 3-locular, each locule with a single ovule; styles 3, lacerate almost to base. *Capsule* usually 3-seeded, enveloped by the slightly accrescent bract. *Seeds* minutely pitted or roughened in rows, carunculate.

A largely New World genus throughout temperate and tropical regions, with about 390 species of annuals, perennials, and subshrubs. Of the 17 species occurring in the U.S., only two are known in Wisconsin.

KEY TO SPECIES

A. Pistillate bracts deeply cut into 6–9 narrowly lanceolate lobes; principal cauline leaves rhombic-ovate, crenate-serrate; stems densely (above) to sparsely (below) pubescent with recurved hairs; common native. . . . . 1. *A. RHOMBOIDEA.*

AA. Pistillate bracts mostly with 9–14 ovate or deltoid shallow lobes; leaves narrowly ovate to broadly lanceolate, slightly crenate to entire; stem with moderately dense incurved or ascending short hairs; rare adventive. . . . . 2. *A. GRACILENS.*

1. ACALYPHA RHOMBOIDEA Raf.
Three-seeded Mercury Map 3, Fig. 3.

Sparsely puberulent annual HERB, 1–4 dm tall, sparingly branched. *LEAVES ovate to rhombic,* 2–8 cm long (mostly smaller), *serrate, glabrate;* stipules inconspicuous; *petioles from one-third to equalling the length of the blade.* INFLORESCENCE small, axillary; pistillate *bracts* 1–3 near the base of each spike, 7–15 mm long, *cut over one-half their length into 5–11 (primarily 7–9) oblong to lanceolate lobes,* usually turning reddish with maturity (particularly the lobes). STAMINATE SPIKES rarely exceeding ♀ bracts, 1.5 cm or less long, bearing 3–9 minute apetalous flowers. PISTILLATE FLOWERS apetalous, 1–3 per bract; ovary 3-locular, each cell with 1 ovule. CAPSULE ca. 2 mm in diameter, pubescent and often glandular at apex. SEEDS ovoid, 1.2–1.7 mm long, brownish or grayish with mottling, with a somewhat shiny minutely roughened surface and a small caruncle.

Distributed over most of the eastern half of N. Am., from s. Que. to Man., south to Tex. and Fla., in Wisconsin common, occurring mostly south of the Tension Zone in a variety of moist to dry

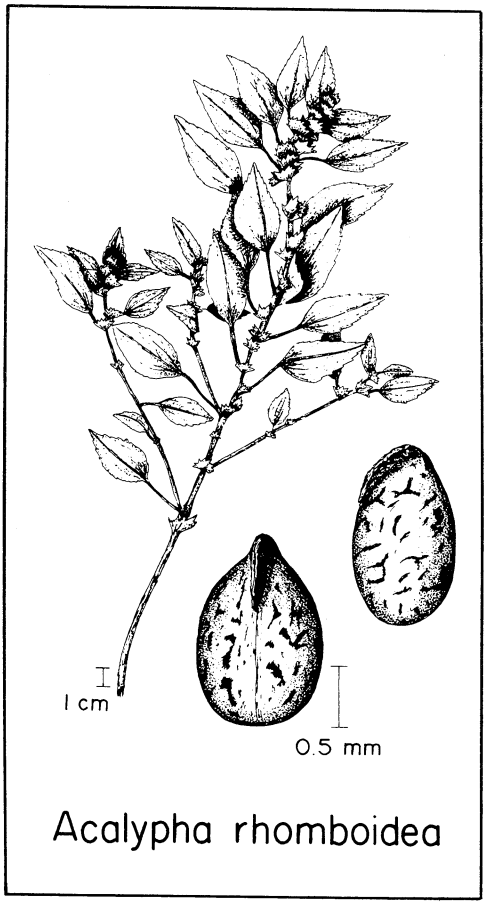


Fig. 3. Habit drawing and seed (ventral and lateral views) of Acalypha rhomboidea.

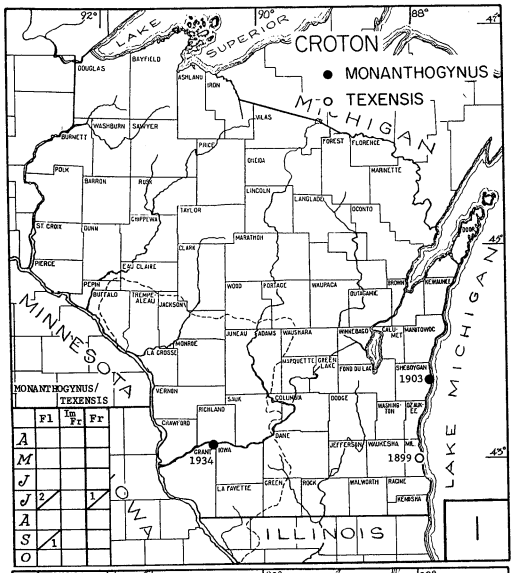
habitats, including mesic woods, river bottoms, and grassy meadows, and as a weed of disturbed ground in farm yards, cities, gardens, fields, pastures, roadsides, ditches, and on stream and pond margins, especially on fill or spoil. Flowering 2 Jul to 2 Sep; fruiting 8 Aug to 24 Oct.

Specimens of *A. rhomboidea* have frequently been misidentified as *A. virginica,* a southern species reaching the Midwest (Ind., Ill., Ia., Mich.) but not yet collected in Wisconsin. *Acalypha virginica* has bracts with 9–12 sharply acute lanceolate lobes; the leaves are narrowly ovate to lanceolate; and the stems and bracts bear long straight hairs. These two species and the next are not always easy to separate.

2. ACALYPHA GRACILENS A. Gray spp. GRACILENS
Slender Mercury Map 4.

Annual HERBS 1–4 dm tall, *sparingly pubescent with short incurved or ascending hairs;* branches slender, somewhat lax to ascending. *LEAVES narrowly ovate-lanceolate to elliptic,* 1.5–4 cm long, pubescent with short stiff appressed hairs; *petioles to 1.5 cm long, less than one-fourth the length of the blade.* SPIKES with 1–3 ♀ flowers near the base, their *bracts* in fruit 5–10 mm long, *cut one-fourth or less their depth into 8–16 lanceolate or deltoid acute to rounded lobes,* pubescent with short stiff hair and usually sessile and long-stalked glands as well. CAPSULE sparsely pubescent and occasionally glandular at apex. SEEDS 1.2–1.6 mm long, golden brown or mottled, the shiny surface with minute pits or regularly roughened in rows.

Native farther south, rare and probably adventive in Wisconsin: Sheboygan Co.: waste places, Sheboygan *(Goessl s.n.,* 29 Aug 1920 [fl], WIS); Green Lake Co.: open red cedar woods, Marquette (*Shinners s.n.,* 30 Jul 1938 [fl], WIS); pastured sandy gravelly slope, same location as Shinners' (*Zimmerman 3625,* 9 Sep 1951 [fl], WIS); Buffalo Co.: weedy pasture bordering Buffalo River (*Hartley 5224,* 8 Aug 1958 [fl], IA-photos MIL, MIN, RIVE, WIS). Hartley's collection bears a close resemblance to the narrow-leaved form of *A. rhomboidea.* Miller (1964) indicated that *A. gracilens* is the only species in the *A. virginica* complex that is common on the Coastal Plain, saying "that the disjunct occurrences in the midwest reflect their being transported into these areas and are not a part of the true range of this species."



	Fl	Im Fr	Fr
A			
M			
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J	2		1
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S	1		
O			

	Fl	Im Fr	Fr
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M			
J	2	2	
J	2		5
A	2	1	7
S	1		6
O			2

	Fl	Im Fr	Fr
A			
M			
J			
J	14	2	
A	24	11	15
S	1	20	91
O			22

	Fl	Im Fr	Fr
A			
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J	1		
A	2		
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A			
M			
J			
J	2	2	1
A	3	7	5
S			7
O			

	Fl	Im Fr	Fr
A			
M			
J			
J		1	3
A	8	13	10
S	2	9	16
O			11

3. **POINSETTIA** Graham

Summer poinsettia, fire-on-the-mountain

Euphorbia subgen. *Poinsettia* (Graham) House

[Dressler, R. L. 1961. A synopsis of *Poinsettia* (Euphorbiaceae). Ann. Missouri Bot. Gard. 48: 329–341.]

Annual *herbs* with milky latex in all parts. *Leaves* alternate near base or opposite or subopposite throughout, petiolate; stipules minute or absent. *Cyathia* in terminal condensed dichasia or pleiochasia; involucre 5-lobed, with a single exappendiculate gland (glands rarely 2 to 5 on early cyathia), enclosing 5 cymules of ♂ flowers at the base of a solitary terminal ♀ flower. *Staminate flowers* numerous, naked. *Pistillate flowers* naked; ovary 3-celled; styles 3, joined at base, bifid for part of their length. *Capsule* 3-celled; *seeds* 1 in each cell, variously roughened; caruncle small or absent.

A New World genus of 11 or 12 species, primarily characterized by its reduced number of deeply cup-shaped exappendiculate glands, condensed terminal dichasial or pleiochasial inflorescences and tuberculate seeds. The cultivated Christmas poinsettia, *Poinsettia (Euphorbia) pulcherrima* (Willd. ex Kl.) Graham, a familiar pot and seasonal garden plant, differs from the wild poinsettias in Wisconsin by being somewhat woody, having considerably larger cyathia and seeds, and displaying many showy white, pink, or red bracts.

KEY TO SPECIES

A. Plants glabrous or with soft pubescence on upper parts; leaves all or mostly alternate, generally with two distinctly different shapes, the cauline leaves narrowly lanceolate to linear, entire, glabrous above, the bracts and bracteal leaves usually lobed or panduriform, typically red at base. . . . . 1. *P. CYATHOPHORA.*

AA. Plants usually strigose-hirsute, especially above; leaves all opposite or subopposite, relatively uniform in shape throughout, the cauline leaves ovate to linear, serrate, sparsely pubescent on both surfaces, the bracts and bracteal leaves green and typically mottled with red spots, usually cream-colored at base. 2. *P. DENTATA.*

1. POINSETTIA CYATHOPHORA (Murr.) Kl. & Gke.

Map 5, Fig. 4.

Painted spurge, painted-leaf

Euphorbia heterophylla of most American authors, not L.

Euphorbia heterophylla var. *graminifolia* (Michx.) Englm.

Poinsettia heterophylla (L.) Kl. & Gke.

Essentially glabrous annuals 3–4 (rarely 10) dm tall; stem erect, branched. *LEAVES alternate near base of plant,* often opposite above; blades variable in size and shape, pandurate, ovate, lanceolate or linear, often assorted on one plant or in the same population, mostly 5–10 cm long, *usually minutely hairy beneath; bracts or leaves* green or *often splashed with red at base,* especially in recent escapes from cultivation. CYATHIA in terminal clusters of 1 to 10, pedicellate; *gland or glands* bilabiate, *sessile,* somewhat appressed to the cyathium. CAPSULE 3–4 mm long, glabrous; *SEEDS* broadly elliptic-ovoid to subglobose, *2.5–3.0 mm long, scarcely angled,* the reddish- to blackish-brown coat finely and sharply tuberculate; caruncle minute or absent.

Native to eastern U. S. and Mexico, now a widespread weed in Tropical and Temperate America and parts of the Old World, in Wisconsin highly variable and much less common than *Poinsettia den-*

tata, with which it sometimes grows. It is found primarily in the Mississippi and Wisconsin river valleys, possibly as a native in sandy woodland on shores (at Lake Pepin) but mostly as an adventive on roadsides, railroad tracks, and in dry weedy places, rarely in disturbed prairies; formerly grown in old-fashioned gardens in the southeastern counties, but apparently not escaped there. It was collected as early as 1861 at Lake Pepin on the Wisconsin side (*T. J. Hale s.n.,* WIS-2 sheets), again at several places along the Mississippi from 1910 to 1914, and about a dozen times since. Flowering (late June) 13 Jul to 26 Aug; fruiting 31 Jul to 27 Sep.

Very variable in vegetative characters, especially in leaf shape and coloration, this species has often been subdivided into varieties or additional species. Plants with mostly unlobed, linear to lanceolate cauline and rameal leaves (var. *graminifolia*) intergrade freely with those whose cauline leaves are ovate to narrowly obovate or pandurate and whose floral leaves may be of either broad or narrow shapes (var. *cyathophora*). It does not seem reasonable to treat plants as distinct varieties based on foliar polymorphism.

This species has long been known as *Poinsettia (Euphorbia) heterophylla,* a name which according to Dressler (1961) should be applied to a tropical American plant whose range hardly extends north of the frost line in Louisiana and Texas.

2. POINSETTIA DENTATA (Michx.) Kl. & Gke. Map 6, Fig. 4.
Toothed spurge
Euphorbia dentata Michx.
Euphorbia cuphosperma (Engelm.) Boiss.
Euphorbia dentata f. *cuphosperma* (Engelm.) Fern.
Poinsettia cuphosperma (Engelm.) Small

Annuals, 2–5 dm tall, the *stem, branches and petioles often strigose-hirsute,* especially toward the tips. *LEAVES opposite or* the upper *subopposite,* petiolate, the blades narrowly ovate to linear, 1–5 cm long, irregularly serrate, *sparsely pubescent on both surfaces; bracteal leaves green* (never red) or *occasionally white or splashed with purple.* CYATHIA in congested terminal cymes of 1 to 10, subsessible, the *gland or glands* bilabiate, *short-stalked* but appressed. CAPSULE 2–3 mm long, 4–5 mm thick, glabrous to lightly strigose; *SEEDS* broadly ovoid to subglobose, (2.2) *2.3–2.6 mm long, inconspicuously 4-angled,* finely and sharply tuberculate, the coat whitish to brown or black; caruncle ca. 0.5 mm long.

Throughout most of the temperate U. S. from Ill. to S.D. and Wyo., east to N.Y. and Va., south to Tex. and Ariz. (also Mex. and possibly Guatemala), native primarily on the Great Plains, locally common in southwestern Wisconsin, sporadic eastward, in dry sandy, gravelly or cindery soil along roads and railroads and in quarries and vacant lots, also on margins of cultivated fields, gravelly hillsides and rocky prairies. This species rarely occurs on very dry limestone (dolomite) bluffs in the Driftless Area, where it appears as if native in prairie remnants virtually free of weeds. However, natural disturbance is always present on these steep rocky prairies, and *P. dentata* is probably adventive rather than native in this ecologically "open" habitat. Significantly, most early Wisconsin collections date from the 1920's and 1930's with the earliest collections dating from 1915 (Lynxville, *Denniston s.n.,* 31 Aug, 1 Sep, both WIS). Flowering from the end of June to 21 Sep; fruiting 18 Jul to 21 Oct.

This species exhibits tremendous variation, particularly in leaf form, and some of these extremes have been given infraspecific or even specific rank. The most distinctive variant is *P. dentata* var.

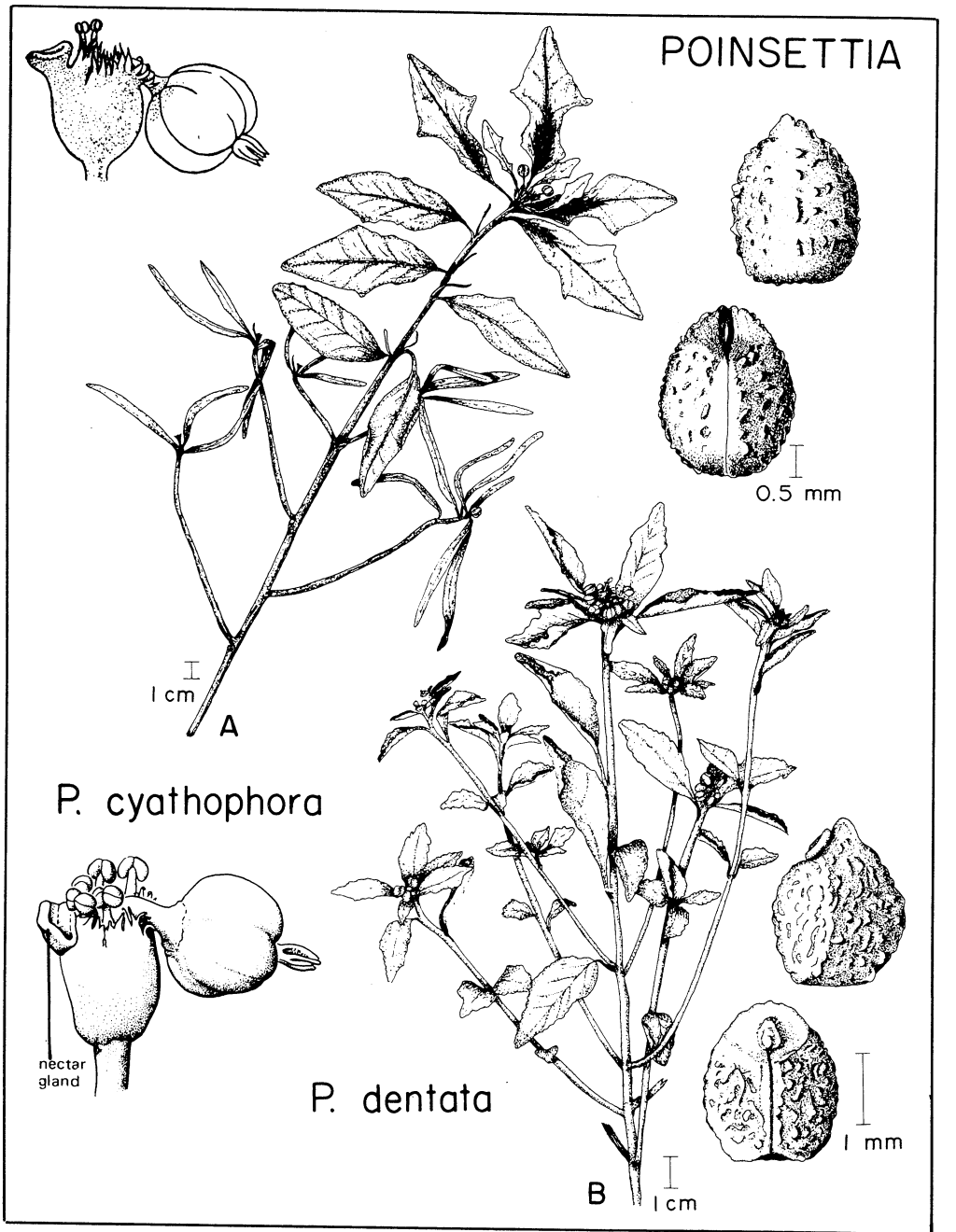


Fig. 4. Habit drawings of Wisconsin Poinsettias: A) Poinsettia cyathophora; *B)* P. dentata. *Left, cyathium, and right, seeds, of respective species. (The cyathium of* P. cyathophora *is redrawn after Dressler 1961, p. 331.)*

cuphosperma, characterized mainly by its narrow leaves, strigose capsules and less strongly tuberculate seeds. Herbarium material from not only Wisconsin and Minnesota but also the Great Plains as well as several individual populations ex-

amined during field work for this report show complete intergradation from the occasional narrow-leaved form to the more typical broad-leaved form (Richardson, 1968 & unpubl. data). Likewise, seed and capsule variants intergrade completely. The reported correlation of strigose capsules with narrow leaves versus glabrous capsules with typical leaf shapes failed completely, because in many specimens with typical var. *dentata* leaves the fruits were pubescent. Plants with strigose capsules occur sporadically and nearly coextensively with other character phases. Furthermore, the amount of pubescence varies in accord with the relative state of capsule maturity on the same plant. In the absence of character correlations it seems rather hopeless to separate our plants into more than one taxon. However, Dressler (1961) indicates that polyploidy is correlated with morphology and that the species does show clinal patterns of variation northward from centers in the Southwest and Mexico.

4. **CHAMAESYCE S. F.** Gray Spurge
Euphorbia subgen. *Chamaesyce* Raf.

[Wheeler, L. C. 1941. *Euphorbia* subgenus *Chamaesyce* in Canada and the United States exclusive of Southern Florida. Rhodora 43:97–154, 168–205, 223–286. Reprinted as Contr. Gray Herb. 136.]

Small, often prostrate annual *herbs* with milky latex in all parts, variously pubescent or essentially glabrous. *Leaves* strictly opposite, petiolate, inequilateral at base, with small interpetiolar stipules. *Cyathia* terminal but appearing axillary, solitary or often clustered; involucre with 5 lobes and 4 glands, with or without obvious petaloid appendages, enclosing 5 cymules of ♂ flowers at the base of a solitary terminal ♀ flower. *Staminate flowers* few to many, maturing serially, naked, monandrous. *Pistillate flowers* pedicellate, naked or with a pad of tissue representing a vestigial calyx; ovary 3-celled, each cell with 1 ovule; styles 3, free or joined at base, bifid for part of their length. *Capsule* 3-seeded; *seeds* small, with a smooth or variously textured surface, ecarunculate.

A genus or roughly 150–250 species, worldwide but with the majority in the New World, represented in Wisconsin by widespread species, all of which occur in open, usually disturbed, dry or less often moist soil.

KEY TO SPECIES

A. Capsules (and ovaries) strigose; stems villous. . . . . 1. *C. MACULATA.*
AA. Capsules glabrous; stems glabrous or ± pubescent (often with only fine incurved hairs).
  B. Leaves entire; seeds terete, smooth (cellular-reticulate under high magnification), the coat usually white.
    C. Capsule ca. 3–3.5 mm long; seeds cuneiform-ovoid (i.e., compressed), 2.3–2.6 mm long; plants of Lake Michigan shore. . . . . 2. *C. POLYGONIFOLIA.*
    CC. Capsule 1.5–1.8 mm long; seeds ovoid (not compressed), 1.3–1.6 mm long; plants widely distributed in western Wisconsin. . 3. *C. GEYERI.*
  BB. Leaves serrulate (at least toward apex or along one side); seeds angular, smooth, punctate or ridged, the coat usually brown or blackish.
    D. Stems pubescent, at least near tips; leaves relatively large (usually more than 10 mm long), toothed along both margins.
      E. Stems erect or ascending, glabrate or crisp-puberulent above,

tending to be pubescent in lines except at the tips; mature leaves usually more than 15 mm long; capsules mostly 1.8–2.3 mm long; stipules entire or toothed. . . . . 4. *C. NUTANS.*

EE. Stems wide-spreading or prostrate, sparsely pilose or hirsute, equally pubescent all the way around; mature leaves mostly less than 15 mm long; capsules 1.5–1.8 mm long; stipules laciniate. . . . . 5. *C. VERMICULATA.*

DD. Stems glabrous; leaves small (mostly less than 10 mm long), toothed only near apex and along one side toward base.

F. Leaves usually linear-oblong, serrulate, obtuse at apex; seeds with 3–7 evident transverse ridges and furrows on each facet. . . . . 6. *C. GLYPTOSPERMA.*

FF. Leaves usually oblong to ovate, entire in lower ⅔, serrulate at the truncate apex; seeds smooth or punctate or with a few faint transverse wrinkles. . . . . 7. *C. SERPYLLIFOLIA.*

1. CHAMAESYCE MACULATA (L.) Small
Map 7, Fig. 5.
Wartweed, milk-purslane
Euphorbia maculata L.
E. supina Raf.
Chamaesyce supina (Raf.) Raf.

Prostrate (usually) to ascending annual *HERBS,* sparsely to densely *villous throughout.* LEAVES oblong to elliptic- or oblong-ovate, 1–2.5 cm long, often with a red-purple blotch, slightly serrulate; stipules distinct, 2- or 3-toothed or cleft. CYATHIA solitary on branches of condensed laterals; glands transversely elliptic, very small, with minute to evident, white or pink appendages. CAPSULE ovoid, 1.3–1.6 mm long, the angles obtuse; seeds oblong-ovoid, 0.8–0.9 (1.2) mm long, 4-angled, *each facet traversed by* 3–5 ± regular *low transverse ridges,* these often passing through the angles; coat tan with white covering.

Native of e. U.S. and s. Canada, now very common is disturbed or waste places from N.S. and s. Que. to N.D., s. to Fla. and e. N.Mex., introduced on the West Coast and in Eu., one of the most abundant weeds in Wisconsin on gravelly and sandy road shoulders, railroad embankments, fallow or cultivated fields, lawns and gardens, and waste ground, also in pastures, open woods, sand prairies, and shores. In addition, this species has the ability to utilize even the rather unique habitat offered by cracks in sidewalks and driveways, and it is commonly associated with other prostrate species of dry barren places (e.g., *Chamaesyce glyptosperma, Mollugo verticillata* and *Polygonum aviculare*). While Fassett (1933) suggested that in northern Wisconsin this species is replaced by *C. glyptosperma,* herbarium collections and field observations indicate that, although the range of the two in the state is very similar, *C. maculata* is the common species in the North. Flowering 12 Jun to 24 Aug with some continuing until frost; fruiting (18 Jun) 4 Jul to 21 Oct or until frost.

This species has had a tortured nomenclatural history. In his excellent study Wheeler (1941) applied *Euphorbia supina* Raf. to it, and his conclusions were adopted by a number of authors, including Fosberg (1953). According to Croizat (1962) and Burch (1966a), however, the epithet *maculata* (=*supina*) must be applied to the prostrate species and the epithet *nutans* to the larger upright one.

An old specimen (*Schuette s.n.,* 1889, F) from Brown Co., cited by Fassett (1933, p. 182) as *Euphorbia humistrata,*

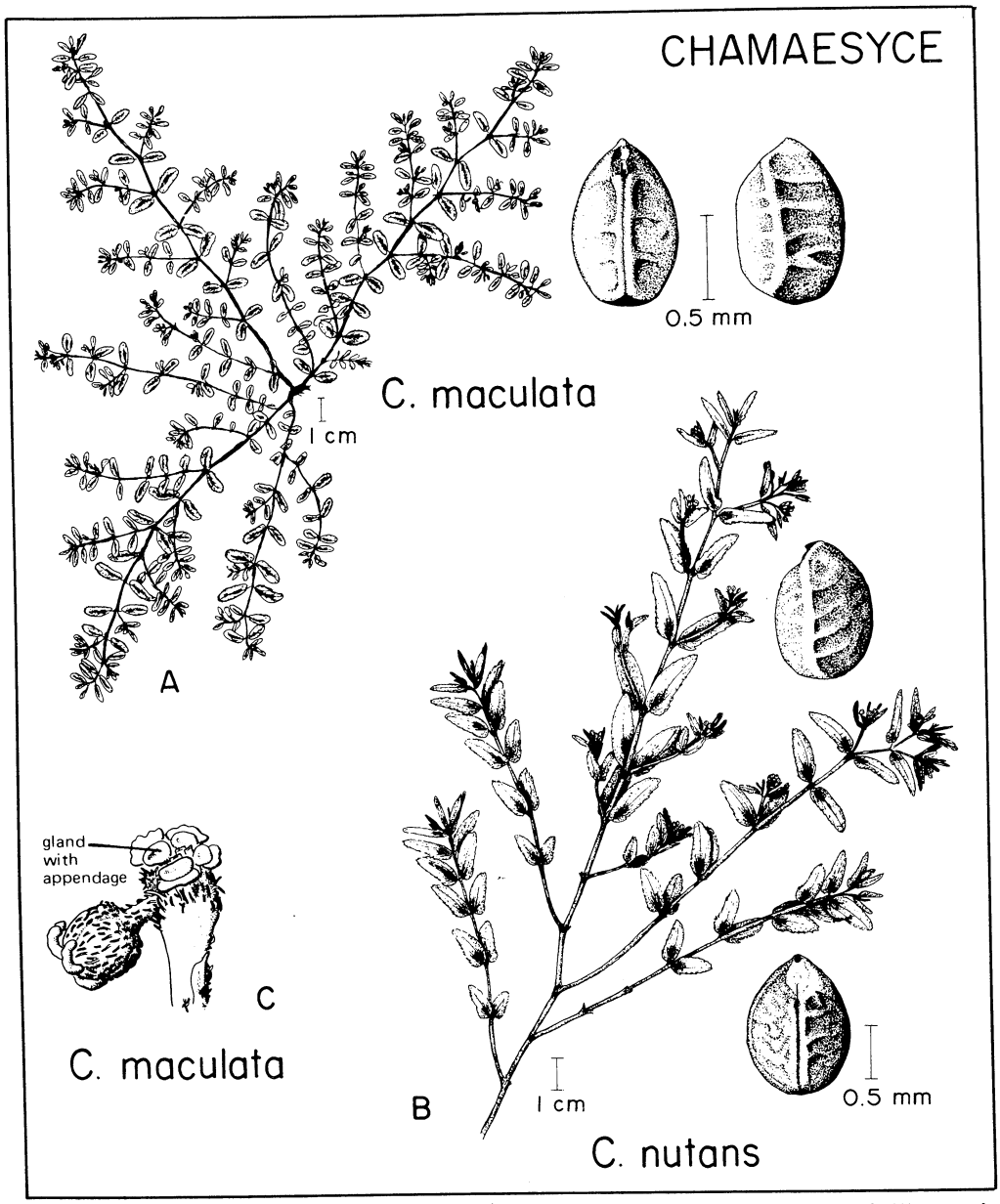


Fig. 5. Habit drawings, seeds (ventral and lateral views), and a cyathium of Wisconsin Chamaesyces: A) and C) Chamaesyce maculata; *B)* C. nutans.

has been annotated as *Chamaesyce maculata.*

2. CHAMAESYCE POLYGONIFOLIA (L.) Small Map 8, Fig. 7.
Seaside spurge
Euphorbia polygonifolia L.

Prostrate, somewhat fleshy annual HERBS forming open mats to 4 dm in diameter, glabrous in all parts. *LEAVES narrowly oblong to oblong-lanceolate,* 5–15 mm long, slightly inequilateral at base, *entire;* stipules deeply 2- to 3-parted or rarely entire or toothed. *CYATHIA*

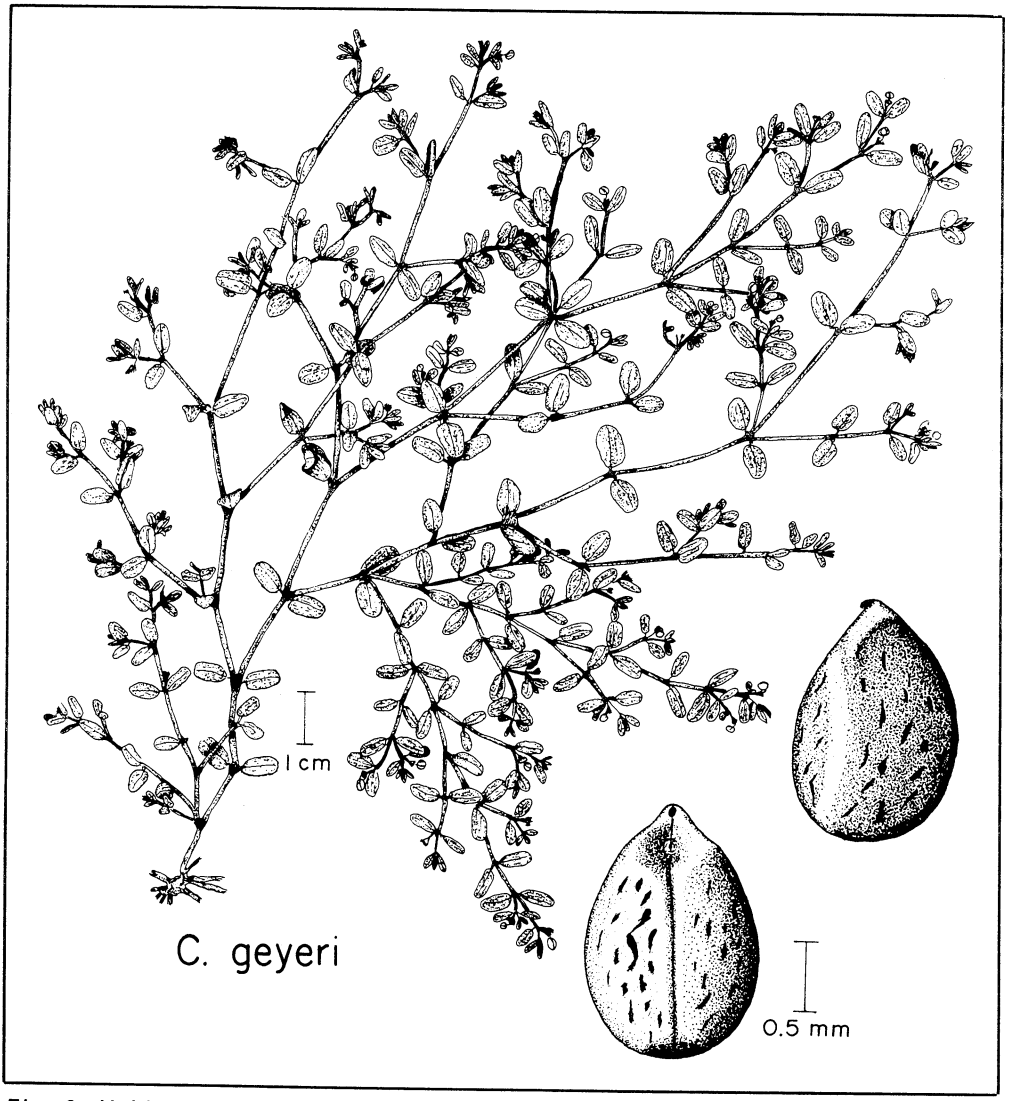


Fig. 6. Habit drawing and seed (ventral and lateral views) of Chamaesyce geyeri.

solitary on branches of short upper laterals; *glands* 4 or often obsolete, broadly oval to suborbicular, *with at most rudimentary appendages. CAPSULE* truncate-ovoid, *relatively large, 2.9–3.6 mm long,* the angles obtuse to rounded. *SEEDS* cuneiform-ovoid, *2.3–2.6 mm long,* the facets slightly (ventral side) to strongly (dorsally) rounded, smooth, whitish-gray.

A characteristic species of sand dunes and sandy or gravelly upper beaches or strands of the Atlantic and Gulf coasts (from e. Que. and N.S. south to n. Fla., also in La.), disjunct to the shores of the Great Lakes (except Lake Superior) in s. Ont. (north to the Bruce Peninsula, Lake Huron), Mich. and Wis., also naturalized in w. Eu. (cf. maps in Cain 1944, Guire & Voss 1963, McLaughlin 1932, Peattie 1922, Wheeler 1941), in Wisconsin restricted to the sand beaches of Lake

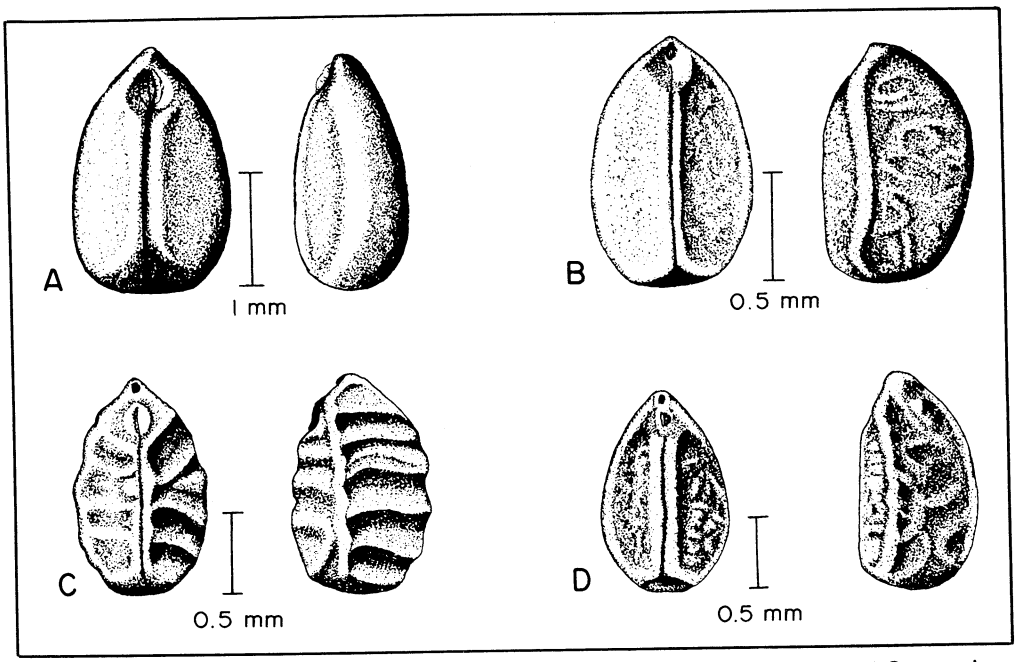


Fig. 7. Seeds of Wisconsin Chamaesyces: A) Chamaesyce polygonifolia; *B)* C. vermiculata; *C)* C. glyptosperma; *and D)* C. serpyllifolia. *Ventral (adaxial) view (left) and lateral view with raphe on the left and micropyle up (right).*

Michigan from Door to Kenosha counties. *Chamaesyce polygonifolia* grows on both the flatter lower strand relatively close to the water's edge, there associated consistently with *Corispermum hyssopifolium, Cakile edentula,* and *C. lacustris* (all likewise annuals), and the looser sand of upper beach dunes, sometimes partly buried and often associated with common dune grasses *(Agropyron dasystachyum* var. *psammophilum, Calamovilfa longifolia* var. *magna, Elymus canadensis, Poa compressa)* as well as *Cyperus schweinitzii, Juncus balticus, Prunus pumila, Oenothera parviflora,* and *Artemisia caudata.* Flowering from 6 Jul to 23 Aug; fruiting from 10 Aug to 15 Oct.

This species is listed as being threatened in Wisconsin (Read, 1976) because of its small number of stations and its dependence on a rare habitat type. During the summers of 1975 and 1976 only a relatively small number of plants were seen at Point Beach State Forest (Manitowoc Co.) and Terrae Andrae State Park (Sheboygan Co.), and later (1985) fewer yet at Sand Dunes Park on Washington Island. The species occupies a very narrow ecological zone, but, being on public land, these populations are under some protection. Additional sites in other counties need similar protection to help ensure the continued existence of not only this critical species but its associates and their rather unique habitat.

A Comment on the Phytogeography of Chamaesyce polygonifolia

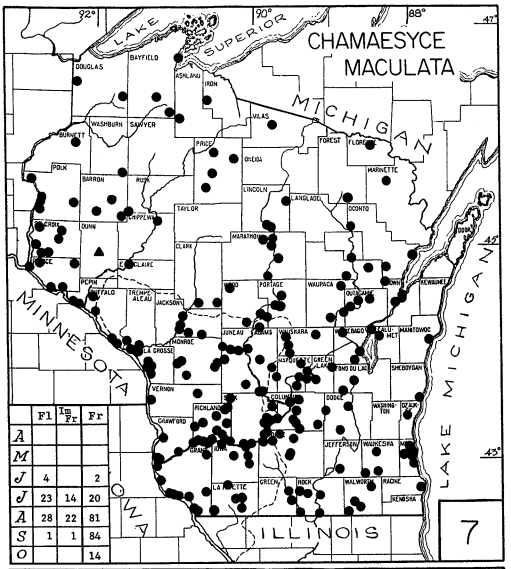
The history of *Chamaesyce polygonifolia* is representative of the many species of the Coastal Plain having inland extensions to the Great Lakes area. Like the majority of such species, seaside spurge is

generally distributed between the Atlantic Coast and Lake Michigan, occurring on the shores of the lower four Great Lakes and the rivers connecting them, as well as coming a short distance up the Hudson River and appearing at a single inland locality (at Onondaga Lake[2]) in the Ontario Basin. Peattie (1922) concluded that this distribution can best be explained in terms of step-wise migration westward in early post-Pleistocene times. A smaller category of Coastal Plain plants is comprised of species with limited inland distributions, including *Muhlenbergia uniflora, Echinochloa walteri,* and *Utricularia resupinata* as well as several strikingly disjunct Cyperaceae (i.e., *Rhynchospora macrostachya, Scleria reticularis, Psilocarya scirpoides, Fuirena squarrosa,* and the oft-cited *Eleocharis melanocarpa*). As for their occurrence in the Midwest, Peattie upheld his answer of the westward migration, suggesting that at the close of the glacial period the Coastal Plain flora was far more extensive than at present and that those species exhibiting geographical discontinuities were simply eliminated from the intervening areas.

Later studies, such as the exhaustive analysis of the sand barrens flora of Wisconsin by McLaughlin (1932), reinforced Peattie's explanation, albeit refining the geographical groupings of plants and giving greater consideration to habitat conditions. Post-glacial migration is a reasonable hypothesis for dune and strand plants, such as *Chamaesyce polygonifolia, Hudsonia tomentosa, Cakile edentula* (s.l.), and *Ammophila breviligulata,* which are distributed along natural avenues of suitable habitats and whose disjunctions involve only short distances.

The possibility of alternative hypotheses ought not to be excluded, however, not only for strictly Coastal Plain species, i.e., those occupying non-littoral habitats, but also for some of the strand disjuncts. According to Svenson (1927), the occurrence of maritime plants inland is generally not controlled by the limits of post-Pleistocene marine submergence. He places considerable emphasis upon transportation of seeds by human agencies and the influence of favorable sites for establishment after dispersal. In discussing *Cakile,* Rodman (1974) postulates that *C. edentula* (as *C. edentula* var. *edentula*) is an historical introduction (perhaps in ballast) to the Great Lakes shores (see also Patman & Iltis 1960, who were not aware of the recentness of this introduction) but that *C. lacustris* (as *C. edentula* var. *lacustris*) is a locally evolved endemic, its progenitors having colonized the region (by ordinary migration) from the Atlantic Coast. The widely disjunct areas of the rare, highly localized Cyperaceae mentioned above imply that these probably arrived in the Midwest via long-distance dispersal, persisting now only locally due to the presence of small special habitats. This pattern also suggests that disjunctions found among other Coastal Plain elements may also have been achieved by long-distance dispersal or a combination of dispersal and migration, as the case may be, rather than only by migration followed by range restriction. It is difficult or impossible to apply one explanation when interpreting distributional disjunctions. The same historical, climatic, and environmental factors that explain the distribution of some plants may not account for the distribution of all species, even among groups having similar geographical patterns, such as *Chamaesyce polygonifolia, Cakile edentula,* and *Cakile lacustris.* Any explanations concerning disjunctions must be settled on a case-by-case basis.

[2] This station has been listed by catalogers of the New York flora (and apparently mapped by Peattie) on the authority of an old floristic list (Goodrich, L. L. H. 1912, p. 123. Flora of Onondaga County: as Collected by Members of the Syracuse Botanical Club. McDonnell Co., Syracuse.)



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M			
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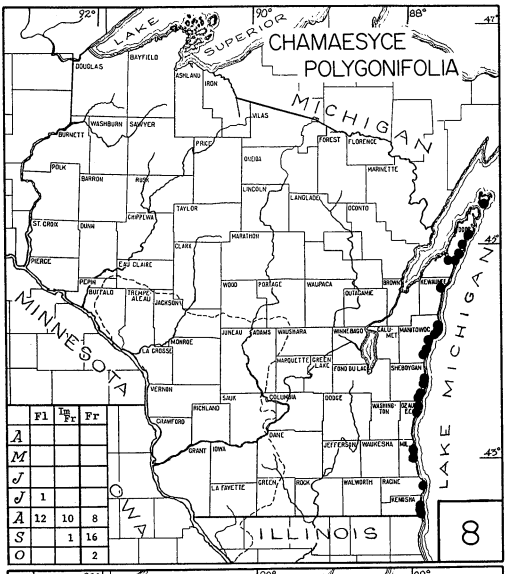
O			14

7



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M			
J			
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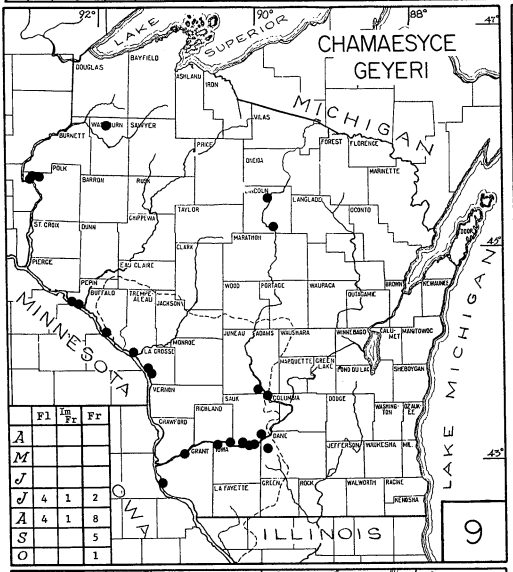
S		1	16
O			2

8



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M			
J			
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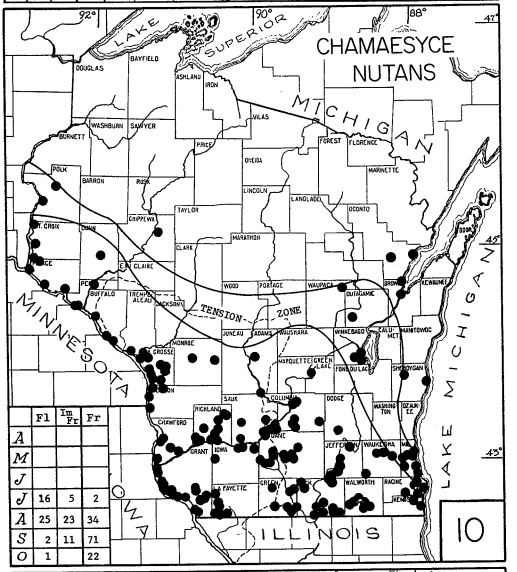
A	4	1	8
S			5
O			1

9



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M			
J			
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O	1		22

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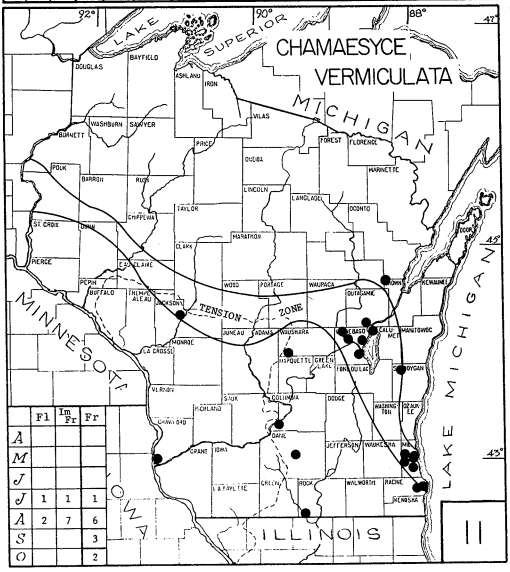

	Fl	Im Fr	Fr
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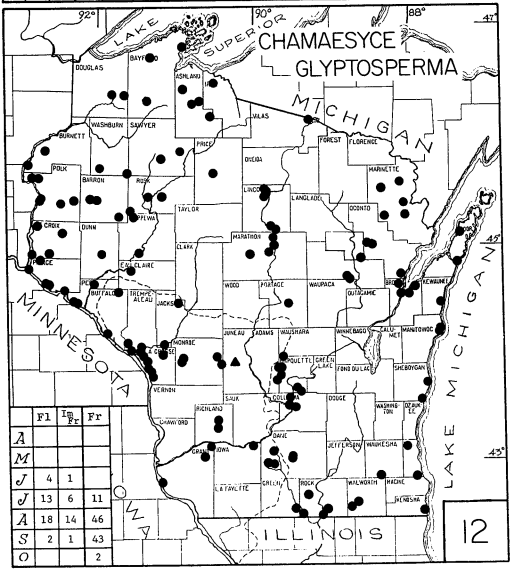
M			
J			
J	1	1	1
A	2	7	6
S			3
O			2

11



	Fl	Im Fr	Fr
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M			
J	4	1	
J	13	6	11
A	18	14	46
S	2	1	43
O			2

12

3. CHAMAESYCE GEYERI (Engelm.) Small
Geyer's spurge Map 9, Fig. 6.
Euphorbia geyeri Engelm.

Glabrous annual HERBS, with prostrate stems forming open mats to 4 dm in diameter. *LEAVES* ovate- to elliptic-oblong, 4–10 mm long, strictly *entire;* stipules deeply 2- to 3-parted. CYATHIA solitary on branches of short laterals; glands broadly oval to suborbicular, the appendages white, smaller than the glands. *STAMINATE FLOWERS* 1–5 (6) per fascicle, *5–27 per involucre. CAPSULE 1.5–1.8 mm long,* strongly lobed, the angles rounded. *SEEDS ovoid, 1.3–1.6 mm long,* the coat smooth, whitish to light reddish-brown or whitish with dark orange mottling due to the testa showing through.

Native to the Great Plains from N.D., Minn. and Colo.. south to n. Ind., Tex. and N.Mex., reaching its eastern range limits primarily in western Wisconsin; also adventive in Upper Mich. Aside from certain sand barrens of northwestern Wisconsin, this species is more or less restricted to the Driftless Area. It is definitely associated with sandy soil, occurring primarily near the larger rivers on dunes (usually stabilized), sand hills, and river banks (e.g., at Cruson Slough, Richland Co., with *Polanisia dodecandra* [sub *Cochrane & Lewicki 3052*] or with such colonizing grasses as *Triplasis purpurea, Eragrostis pectinacea, Elymus canadensis, Digitaria ischaemum,* and *Panicum virgatum* [sub *Cochrane & Cochrane 7083*]), blowouts and sand pits, and sandy waste areas and barrens. Although not widely distributed, *C. geyeri* does tend to be locally common, particularly in abandoned agricultural fields, margins of prairie remnants and roadsides. Flowering 12 Jul to 17 Aug; fruiting 26 Jul to 2 Oct.

Although not given protective status, this species might be deserving of reconsideration for listing once its status can be more thoroughly investigated (Read, 1976).

This species is commonly confused with *C. glyptosperma* but may be easily distinguished from the latter by the entire leaves, higher number of staminate flowers per cyathium, and smooth whitish seeds.

4. CHAMAESYCE NUTANS (Lag.) Small
Eyebane Map 10, Fig. 5.
Euphorbia nutans Lag.
E. preslii Guss.
E. maculata L. sensu Wheeler and others

Suberect to ascending annual *HERBS* 8–30 cm tall; stems mostly simple below, short-pubescent at tips and in 1 or 2 lines on young shoots, glabrate. *LEAVES* ovate-lanceolate to oblong, often somewhat falcate, *1–4 cm long, serrulate,* glabrous or sparsely long-pilose particularly beneath, typically red-mottled; *stipules* connate or distinct, triangular, *entire or toothed.* CYATHIA both solitary and clustered in lateral and terminal short-stalked compound dichasia; glands transversely elliptic to circular, the appendages obsolete or up to 3 times the width of the gland, white or pink. *CAPSULES* broadly ovoid, when mature (1.6) *1.8–2.4 mm long,* strongly lobed, the angles subacute, glabrous. SEEDS oblong-ovoid, 1.1–1.3 mm long; ventral angle rounded, the others well marked, the 4 unequal *facets* flat to slightly convex, *rippled or transversely wrinkled* by several (5–9) low irregular ridges; coat dark gray to dark brown with angles usually lighter in color.

Widespread in warm-temperate parts of the world, including eastern N. Am. and the Great Plains, from Que. to N.D., south to Fla. and Tex. (introd. in Wash., Calif.), relatively common in the southern half of Wisconsin, particularly along the Mississippi and Wisconsin rivers. Generally considered a weed, it is common in

sandy, gravelly or cindery soils along railroad embankments, roadsides and dry open ground, also on flood plains, shores and ditches, disturbed spots in woods and prairies, hillsides, waste or cultivated fields, and pastures. *C. nutans* is very rare north of the Tension Zone and then only along railroad embankments or roadsides, which apparently provide temporary avenues into that portion of the state. Even once established, dispersal seems to be restricted, few, if any, plants invading adjacent areas, the populations tending to remain small. South of the Tension Zone dispersal is much more efficient or the climate more agreeable, because the species is relatively widespread and occurs in a variety of habitats. Flowering 9 Jul to 30 Aug (15 Oct); fruiting 24 Jul to 24 Oct.

Much controversy has centered around the correct name for this distinct, semierect glabrate species. Burch (1966a) disagreed with Wheeler's (1941) interpretation of the Linnaean *E. maculata,* indicating that due to the established usage of *E. hypericifolia* for the tropical or subtropical species, the epithet *nutans* should be applied to the upright northern species. Also, since the specimen used by Wheeler as the type for *E. maculata* was not in Linnaeus' possession until after the publication of *Species Plantarum,* the name *E. maculata* must be rejected for this species and applied to our species no. 1 (see comments under *E. maculata*).

5. CHAMAESYCE VERMICULATA (Raf.) House — Map 11, Fig. 7.
Hairy spurge
Euphorbia hirsuta (Torr.) Wieg.
E. rafinesquii Greene

Prostrate (usually) to ascending annual HERBS; *stems* to 4 dm long, *sparsely long-pilose* at least in a line on the upper side and extending down to internode from the stipules. LEAVES obliquely ovate to lanceolate, (5) 8–15 (18) mm long, glabrous or sparsely pilose above, usually pilose beneath, serrulate; *stipules* distinct or united, *usually deeply cleft.* CYATHIA solitary, the uppermost sometimes appearing clustered by the condensation of a small leafy cyme; glands long-stipitate, subcircular, the *appendages usually prominent,* white. *CAPSULE* broadly ovoid, *1.5–1.8 mm long,* glabrous or rarely pilose and glabrate, the angles rounded. *SEEDS* ovoid, 1.1–1.2 mm long, *quadrangular,* gray-brown, slightly wrinkled, the *ventral facets slightly concave,* the dorsal flat to slightly convex.

Locally common in the northeastern U.S., reaching its western range limits in Wisconsin (except for B.C., Ariz., and N. Mex., where introd.?), considered native but generally found in waste ground and disturbed sites, such as railroads, roadsides, ditches, parking lots, city streets, occasionally yards and gardens. This species is sporadic in southern Wisconsin; field observations indicate that even where *C. vermiculata* is found, individual plants are widely scattered. Flowering July through September (collected specimens: 17 Jul to 10 Aug); fruiting 5 Aug to 14 Oct.

6. CHAMAESYCE GLYPTOSPERMA (Engelm.) Small — Map 12, Fig. 7.
Ridge-seeded spurge
Euphorbia glyptosperma Engelm.

Prostrate or ascending glabrous annual HERBS; stems 5–30 cm long. *LEAVES narrowly oblong to ovate-oblong,* 3–15 mm long, strongly inequilateral, serrulate; stipules usually connate, subulate or deeply cleft into filiform divisions. CYATHIA solitary on branches of short laterals; glands transversely elliptical, often much reduced, the appendages from shorter than to equalling the glands or absent, white to reddish. *STAMINATE FLOWERS* (0) 1–2 per fascicle, *2–7* (usually 4) *per involucre.* CAPSULE depressed-ovoid, 1.3–1.6 mm long, the angles obtuse. SEEDS oblong-ovoid,

0.9–1.0 mm long, strongly 4-angled, the *ventral facets concave, traversed by 3–5 prominent ridges,* the *dorsal facets convex, traversed by 5–7 prominent ridges,* the ridges ± passing through the angles; coat tan but appearing white due to thick bloom.

Widespread from N. Engl. south to Tex. and west to B.C. and n. Calif., in Wisconsin a very common weed of roadsides, railroads, sand or gravel pits, waste areas, and in virtually every available habitat with open, rather dry sandy, gravelly, or loamy soils: driveways, fire lanes, paths, lake shores, prairies, pine plantations, plowed fields, lawns, playgrounds, parking lots, cliffs, ledges, outcrops, and talus. It frequently occurs with *Chamaesyce maculata,* the two species apparently having very similar ecological requirements, both being well adapted to man-made disturbances and common in cracks of sidewalks or driveways, baseball diamonds, tennis courts, etc. Flowering 20 Jun to 7 Sep (October); fruiting 1 Jun to 6 Oct.

See notes under *C. geyeri* (no. 3) and *C. serpyllifolia* (no. 7).

7. CHAMAESYCE SERPYLLIFOLIA (Pers.) Small Map 13, Fig. 7.
Thyme-leaved spurge
Euphorbia serpyllifolia Pers.

Prostrate or ascending annual HERBS, glabrous in all parts; *stems* 5–30 cm long, *often* (at least the distal internodes) *flattened in the plane of the leaves. LEAVES* variable in shape, *oblong, spatulate or obovate,* 3–14 mm long, strongly serrulate above the middle, typically red-mottled above along the midrib; stipules distinct, deeply 2- or 3-parted into linear segments. CYATHIA solitary; glands transversely oblong, the appendages very small, white. *STAMINATE FLOWERS* 1–3 per fascicle, *5–12 (18) per involucre.* CAPSULE ovoid, 1.3–1.9 mm long, glabrous, the angles obtuse. SEEDS oblong-ovoid, 1.0–1.2 mm long, strongly 4-angled; *facets essentially smooth, punctate, or sometimes with faint transverse wrinkles,* the coat gray- to yellow-brown with a thick bloom.

Primarily in the western states and the northern Great Plains from B.C. east to Alta., south to Tex., N. Mex., and Baja Calif., extending east to Minn., Ia., Wis., and n. Mich.; only rarely collected in sites with undisturbed vegetation. In Wisconsin it is weedy and probably adventive, the limited number of collections (ca. 12) sporadically distributed north of the Tension Zone, most often along railroads and roadsides but rarely in other disturbed sites (i.e., drained river bed, ditch, and "dry soil"). Flowering July and August; fruiting from 19 Jul through September.

Chamaesyce serpyllifolia and *C. glyptosperma* are similar and frequently grow together. In both species the leaf blades are very variable in shape and often appear bowed-in along the sides due to the revolute margins. However, *C. serpyllifolia* tends to be relatively robust and decumbent to ascending in habit. Also, its seeds are rather smooth to somewhat rugulose, and the red-mottled spatulate to obovate leaves have the margins unthickened and serrulate for less than half the length from the apex. *Chamaesyce glyptosperma* is slender and typically prostrate. It has seeds with prominent transverse ridges and oblong to subfalcate leaves with thickened margins whose serrulations often extend to the base on the lobed (abaxial) side.

5. **EUPHORBIA** L. Spurge
Euphorbia L. subgen. *Esula* Pers.
[Richardson, J. W. 1968. The Genus *Euphorbia* of the High Plains and Prairie Plains of Kansas, Nebraska, South and North Dakota. Univ. Kansas Sci. Bull. 48:45–112.]

Erect annual or perennial *herbs* with milky latex in all parts; stems scarcely

branched for much of their length, then umbellate or branching freely (sometimes dichotomously) above. *Leaves* alternate near the base, opposite or alternate above and usually verticillate below the branches (rays) of the umbel, mostly estipulate; blades in shape and character often changing serially up the stem and on the fertile branches. *Inflorescence* of cyathia, terminal, clustered or usually umbellate; cyathium 5-lobed, with 4 or 5 glands and with or without petaloid appendages, enclosing 4–5 cymules of ♂ flowers at the base of the solitary ♀ flower. *Staminate flowers* naked, few to many, maturing serially. *Pistillate flowers* naked, the ovary 3-celled, each cell with 1 ovule; styles 3, ± joined at the base and bifid for part of their length. *Capsule* 3-seeded. *Seeds* with or without a caruncle.

The largest genus in the family, with perhaps 1600 species as circumscribed by Linnaeus and later by Pax and Hoffmann (1910–1924). Some workers, appalled by the heterogeneity of this group, have suggested that *Euphorbia* s. str. should include only a few of the woody or succulent African species and that the remainder should be divided among a number of more "natural" genera. Further work may show that this course should be followed, but until other segregates can be unequivocally defined, we are accepting as distinct genera in addition to *Euphorbia* only the easily recognizable *Chamaesyce* and *Poinsettia*.

Several exotic spurges have been introduced into North America as ornamental plants. Of these, cypress spurge (*Euphorbia cyparissias* L.) and leafy spurge (*E. esula* L.) are now persistent weeds in practically every county in Wisconsin. The European *Euphorbia myrsinites* L., a perennial with glaucous fleshy stems, alternate, obovate to suborbicular leaves, and dilated, 2-horned glands, was collected at Oshkosh by Harriman (*s.n.*, 2 Jun 1971 [im fr], OSH-photos MIL, RIVE, UWM, WIS) as an adventive in his garden that did not reappear in subsequent years.

KEY TO SPECIES

A. Glands of the cyathia with conspicuous white appendages; seeds ecarunculate [subgen. *Agaloma* (Raf.) House].
  B. Capsules and involucres pubescent; seeds 3–4 mm long, tuberculate or reticulate-verrucose; upper leaves and bracts conspicuously white-variegated; plant annual [sect. *Petaloma* Boiss.]. . . . . 1. *E. MARGINATA*.
  BB. Capsules and involucres glabrous (variously pubescent when young); seeds 2–2.5 mm long, smooth or with indistinct rows of shallow depressions; all leaves green; plant perennial [sect. *Tithymalopsis* (Kl. & Gke.) Boiss.]. . . . . 2. *E. COROLLATA*.

AA. Glands of cyathia without petaloid appendages; seeds carunculate [subgen. *Esula* Pers.].
  C. Leaves entire; glands of involucre lunate, their tips pointed or prolonged into short horns [sect. *Esula* (Roeper) Koch].
    D. Stem leaves broadly ovate to obovate; seeds pitted; inflorescence with usually 3 primary rays; plants annual (or short-lived perennial in *E. commutata*).
      E. Capsule ca. 3 mm long, without keels; seeds finely and uniformly pitted on all facets, broadly carunculate. . 3. *E. COMMUTATA*.
      EE. Capsule ca. 2.5 mm long, with 2 longitudinal keels on each lobe; seeds with 4 vertical rows of large pits on the outer facets and 2

longitudinal furrows on the inner, minutely carunculate. ..... 4. *E. PEPLUS.*

DD. Stem leaves linear to linear-spatulate or lanceolate; seeds smooth; inflorescence with 5 or more rays; plants perennial.

F. Principal cauline leaves 1–3 cm long, 1–3 mm wide, densely crowded; style plus stigma shorter than the young exserted ovary; plant with many stems from strong horizontal rhizomes. ..... 5. *E. CYPARISSIAS.*

FF. Principal cauline leaves 3–7 cm long, mostly 3–10 mm wide, less numerous; style plus stigma equalling or exceeding the immature capsule in length; plant with fewer stems from deeper rootstocks. ..... 6. *E. ESULA.*

CC. Leaves finely serrate; glands of involucre elliptic or suborbicular [sect. *Tithymalus* Roeper].

G. Capsules verrucose; seeds lenticular, nearly smooth; floral leaves ± cordate-clasping; rays of primary inflorescences 3. 7. *E. OBTUSATA.*

GG. Capsules smooth; seeds ovoid-subglobose, conspicuously reticulate-rugose; floral leaves tapered to base; rays of primary inflorescences 5. ..... 8. *E. HELIOSCOPIA.*

1. EUPHORBIA MARGINATA Pursh
Snow-on-the-mountain Map 14.

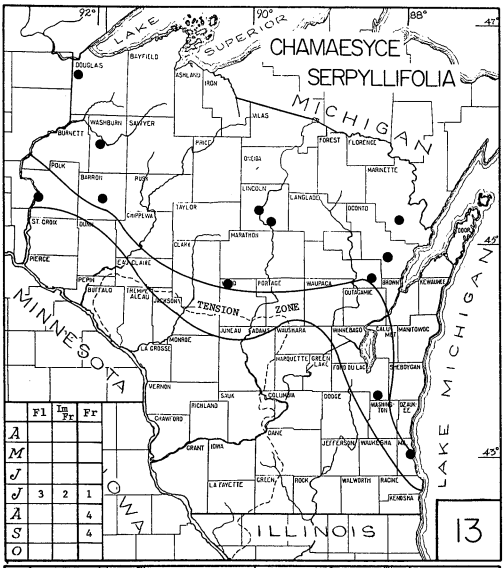
Subglabrous to densely villous (especially on younger parts) *annual HERBS;* stems 3–9 dm tall, unbranched below the rays of the terminal inflorescence. LEAVES alternate, estipulate, subsessile, the *blades* broadly ovate to elliptic, 3–9 cm long, *mucronate;* whorl of leaves at base of umbel (ray leaves) and floral leaves similar, *those pairs near the cyathia* narrower and *with broad white margins. Rays of umbel 3* (rarely 4 or 5), simple or dichotomously branched; CYATHIA with 4 (usually) or 5 oblong light to dark green glands, *each with a large white appendage* wider and longer than the gland. *CAPSULES* depressed-globose, ca. 5 mm in diameter, *pubescent.* SEEDS ovoid-globose, ca. 3–4 mm long, the white to tan coat tuberculate or reticulate-verrucose, ecarunculate.

Native from Tex. to N.M. and on the central and southern Great Plains, escaped from cultivation farther north and east, in Wisconsin cultivated for ornament and occasionally escaped in the southern half to dumps, vacant lots, roadsides, railroads, abandoned fields, farm yards, and other waste places. Flowering 27 Jul to 20 Sep; fruiting 31 Aug to 10 Oct.

Contact with the milky sap of *E. marginata* produces inflammation and blistering of the skin in many people.

2. EUPHORBIA COROLLATA L.
Maps 15, 16; Figs. 1, 8.
Flowering spurge

Glabrous or variously villous *perennial HERBS,* 3–10 dm tall, usually unbranched below. LEAVES alternate, estipulate, subsessile, the *blades* elliptic, oblong or linear, 2–6 cm long, *obtuse to retuse,* the whorl at the base of the umbel similar but usually smaller, the floral leaves opposite, smaller and narrower than the others, some with a small light-colored margin. *INFLORESCENCE* umbellate, the primary rays 3–6, usually dichotomously branched at least twice and with other branches from the upper nodes reaching the same level to form *a large corymbiform or paniculate cyme.*



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M			
J			
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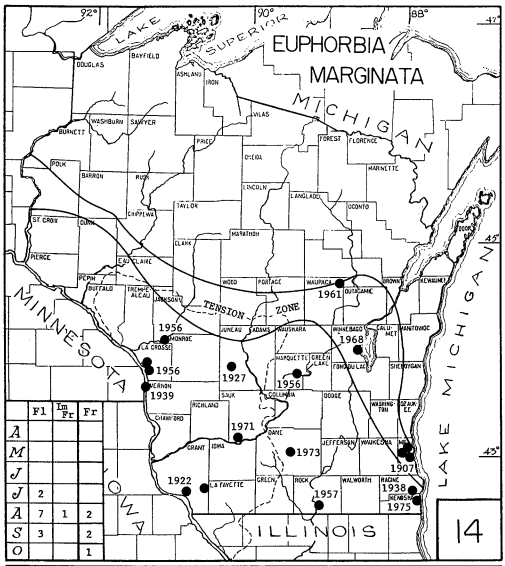
A			4
S			4
O			

13



	Fl	Im Fr	Fr
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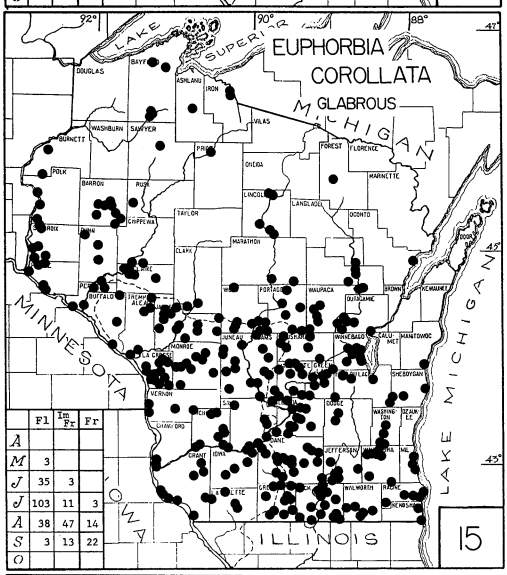
M			
J			
J	2		
A	7	1	2
S	3		2
O			1

14



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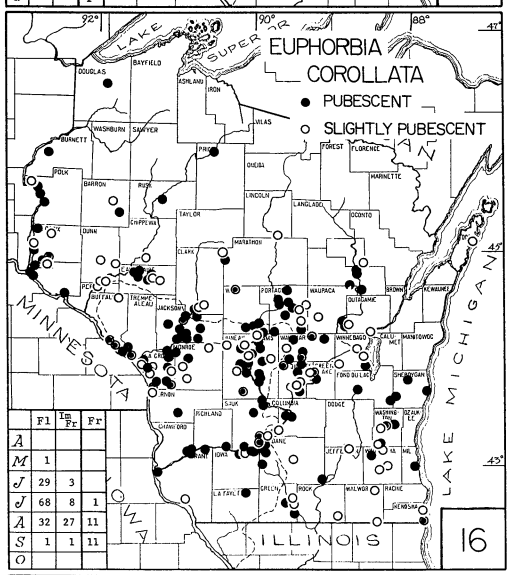
J	103	11	3
A	38	47	14
S	3	13	22
O			

15



	Fl	Im Fr	Fr
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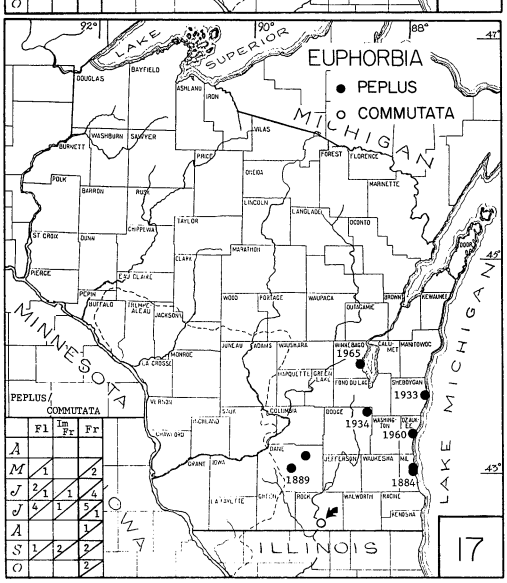
M	1		
J	29	3	
J	68	8	1
A	32	27	11
S	1	1	11
O			

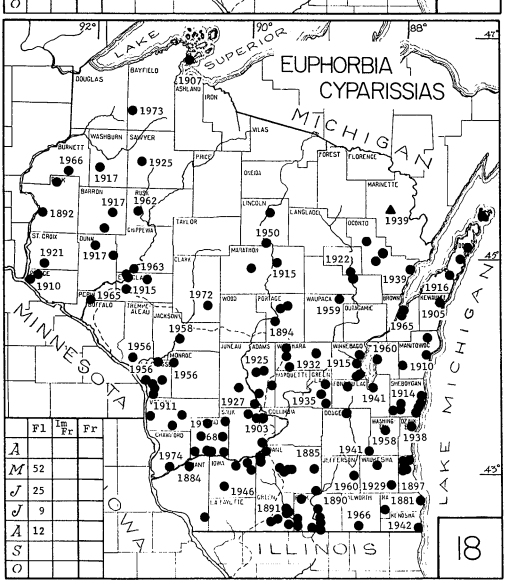
16



PEPLUS / COMMUTATA

	Fl	Im Fr	Fr
A			
M	1		2
J	2	1	4
J	4	1	5
A			1
S	1	2	2
O			2

17



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J	25		
J	9		
A	12		
S			
O			

18

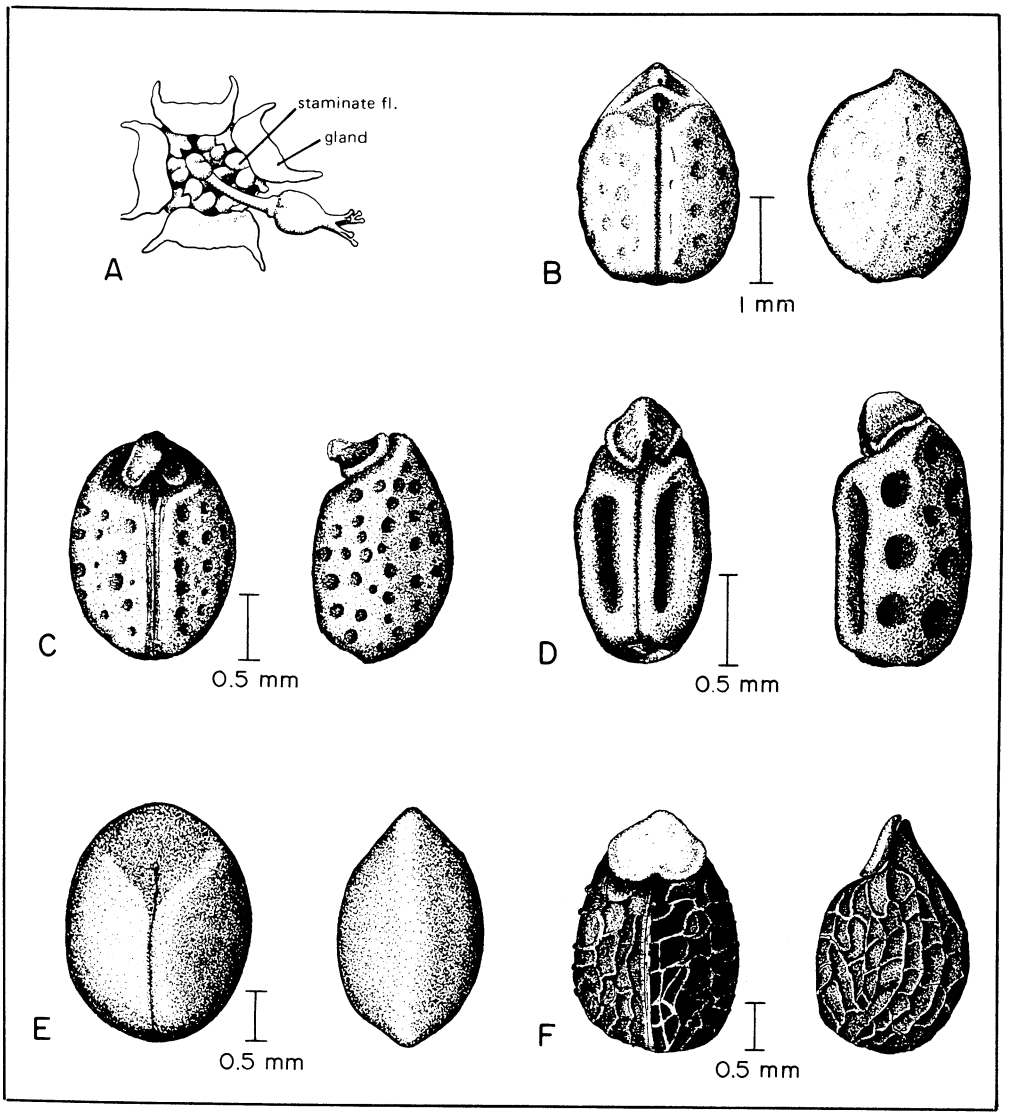


Fig. 8. Seeds and a cyathium of Wisconsin Euphorbias: A) and C) Euphorbia commutata; *B)* E. corollata; *D)* E. peplus; *E)* E. obtusata; *and F)* E. helioscopia. *Cyathium from above; seeds in ventral view (left) and lateral view (right).*

CYATHIA with 5 small yellowish-brown *glands, each with a showy bright-white appendage. CAPSULES* 3–3.8 mm long, *glabrous or nearly so.* SEEDS white to gray, ovoid, 2.1–2.7 mm long, smooth or with shallow depressions arranged in irregular longitudinal rows, ecarunculate.

Widespread in the eastern U.S. and Great Plains on dry to moist, sandy or loamy soils of open woodlands and clearings, prairies, and abandoned fields, in Wisconsin this conspicuous species prevalent in a number of native communities (Curtis 1959), especially in open, sandy or gravelly sunny places, in prairies, thin jack pine or scrub oak woods, barrens and cedar glades, sandstone ridges, limestone bluffs, sand flats, blowouts, and

lake shores, commonly weedy in abandoned fields, roadsides, railroads, fencerows, and occasionally quarries or city lots, primarily in the southern two-thirds of the state. As Fassett (1933) indicated, the occurrence of the species in northern Wisconsin presumably results from the plant's having spread along railroads and highways beyond its native range, which possibly reaches as far north as St. Croix, Wood, and Outagamie counties. The overall distribution of the species has barely changed since Fassett's study. Curiously, the earliest Wisconsin specimen seen is from Racine County and was not collected until 1892, although *E. corollata* was listed in a number of early reports, beginning with Lapham (1836). Subsequently, collections became increasingly common, the species being known from Lincoln Co. as early as 1893 and several other northern counties by the 1910's. It was probably spreading rapidly northward soon after the turn of the century. Flowering 27 May to 1 (21) Sep; fruiting 8 Jul to 27 Sep, dispersed as early as (8) 24 Aug.

Several species and/or varieties have been segregated from the extremely variable *E. corollata* complex. These include: var. *corollata,* which is glabrous and has the cyathia on loosely forked inflorescences, pedicels (at the dichotomy) 7–30 mm long, and appendages 7–10 mm broad; var. *paniculata* (Ell.) Boiss., also glabrous, characterized by more crowded cyathia on shorter pedicels (0.5–5 mm long) and relatively small appendages (5–7 mm broad); and var. *mollis* Millsp., distinguished from var. *corollata* by soft pubescence on the stem and on the surfaces of the leaves. Delimiting varieties on such characters as leaf width, peduncle length, pubescence, and appendage width in our area is of no value because variation on an individual plant can, in many cases, incorporate the spectrum of variability. For example, in the most commonly recognized variety, var. *mollis,* there is complete intergradation in Wisconsin between plants possessing stems and leaves with dense, almost woolly pubescence; those with glabrous stems but one or both leaf surfaces glabrous to densely hairy; and others completely glabrous. Gleason (1952) and Steyermark (1963) both state that the presence or absence of pubescence appears to be an environmental response, the more pubescent plants being found in drier exposed situations. Richardson (1968) found no correlation between pubescent forms and drier habitats on the Great Plains, and his studies (unpubl.) did not confirm any demonstrable trends in Wisconsin for increased pubescence on drier sites. Furthermore, glabrous and pubescent forms can usually be found not only in the immediate vicinity of one another, but sometimes also mixed within one population. Where variously pubescent forms were found in a given colony, they were the most abundant (almost 60% of the plants); the remaining 40% were completely glabrous. These percentages appear to hold fairly true for mixed populations across the state.

3. EUPHORBIA COMMUTATA Engelm.

Map 17, Fig. 8.

Wood spurge, tinted spurge

Delicate glabrous perennial HERBS, the stems ascending, 2–4 dm tall, branching throughout their length. LEAVES broadly ovate to obovate or oblanceolate, 2–4.5 cm long, those in the whorl at the base of the umbel somewhat broader, the *floral leaves and bracts* subtending cyathia opposite, broader yet *(slightly broader than long),* broadly triangular-reniform and sometimes connate or enveloping the stem. UMBEL lax, with only 3–4 primary rays but these dichotomously branched; glands of cyathium 4, dark, lunate, extended into slender horns twice as long as the breadth of the body, occa-

sionally deeply toothed. CAPSULES 2.7–2.9 mm long, smooth. *SEEDS* 1.9–2.0 mm long, *deeply and uniformly pitted,* dark gray, with a broad thin caruncle.

Infrequent in the eastern U.S. deciduous forest, extending as far west as Minn. to Tex. along streams and ponds in moist woods, also on wooded hillsides or cliffs on or about calcareous soils, native though very rare in Wisconsin, where known only from Big Hill Park, on the west side of Rock River 3½ miles north of Beloit, Rock County. It has been collected there several times, beginning with T. J. Hale in 1861. The wooded riverine terrace where this population still occurs is on public land and should enjoy protection from future destruction. Flowering May and early June; fruiting 30 May to 6 Jul.

4. EUPHORBIA PEPLUS L. Map 17, Fig. 8.
Petty spurge

Glabrous annual HERBS; stems erect, 1–3 dm tall, freely branching throughout their length. LEAVES alternate, estipulate, petiolate (petioles up to 8 mm long); blades ovate to obovate, 1–2.5 cm long, larger and subsessile in the whorl at the base of the umbel; *floral leaves and bracts* subtending the cyathia opposite, similar in shape to the cauline leaves *(slightly longer than broad).* CYATHIA in a leafy dichotomously branched umbel; glands of cyathium 4, lunate, greenish-yellow, exappendiculate. CAPSULES 1.9–2.1 mm long, each valve with 2 longitudinal keels. SEEDS oblong, 1.5–1.6 mm long, the *dorsal surface with four rows of large pits, the ventral with two longitudinal furrows,* ash-gray, with a ± inconspicuous conical caruncle.

Native of Eurasia, now a locally established weed across much of N. Am., in Wisconsin collected rarely (only twice since the mid-1930's) in the southeast quarter of the state as an inconspicuous weed of yards, gardens, vacant lots, and waste or cultivated ground. Flowering 28 Jun to 13 Sep; fruiting 8 Jul to 18 Oct.

5. EUPHORBIA CYPARISSIAS L.
Map 18, Fig. 9.
Cypress spurge, graveyard spurge

Glabrous *perennial HERBS from extensively creeping rhizomatous rootstocks;* stems solitary or tufted, erect, 1–4 (7) dm tall, unbranched at the base, often with numerous sterile branches and several axillary rays above. Cauline *LEAVES* alternate to scattered, *very numerous,* narrowly oblong to linear, linear-filiform, or linear-spatulate, *1–3 cm long;* inflorescence leaves and bracts subtending the cyathia opposite, broadly cordate to ovate and often yellow to red or purple in age. UMBEL with (6) 9–18 rays, simple or 1–3 times dichotomously branched. Glands of cyathium 4, lunate, yellow-green, exappendiculate. CAPSULES ca. 3 mm long, rarely produced, glabrous, rugulose and with short round tubercles along either side of the sutures. *SEEDS* (when present) oblong-ovoid, 1.5–2 mm long, brownish-gray to silvery-white, *never mottled,* smooth, with a papilliform caruncle.

Native of Eurasia, widely grown as a ground cover and well established as an escape in the northern states and Canada from Me. to Minn. and Colo., south to Va. and Mo., occasionally adventive in nw. U.S., common throughout most of Wisconsin along roadsides, railroads, banks, fields, clearings, and other neglected areas, often spreading from unkempt lawns, old homesites, and cemeteries. If not controlled, cypress spurge can become a serious weed, forming persistent colonies from extensively creeping and forking rhizomes. Our earliest collections are from 1881 and 1894 in Racine and Portage counties, respectively. Flowering from April through August (inflorescence: 20 Apr to 14 Jun; lateral shoots: 22 Jun to 28 Aug); fruiting, when it occurs, appears to be from June through

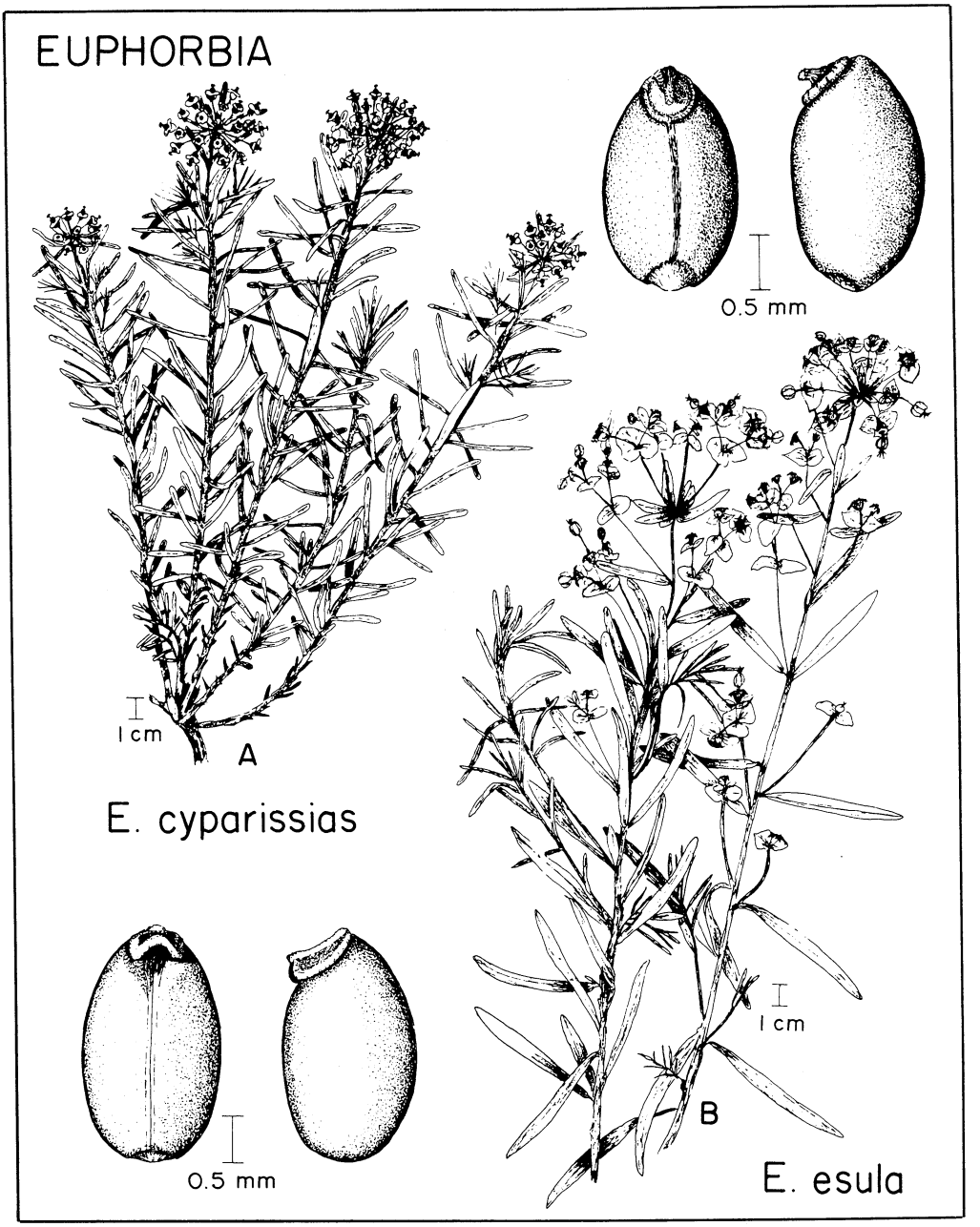


Fig. 9. Habit drawings and seeds (ventral and lateral views) of Wisconsin Euphorbias: A) Euphorbia cyparissias; *B)* E. esula.

August or September. Fruits are rarely produced, and specimens with viable seeds are even fewer (in examined capsules, two of the three developing chambers were aborted).

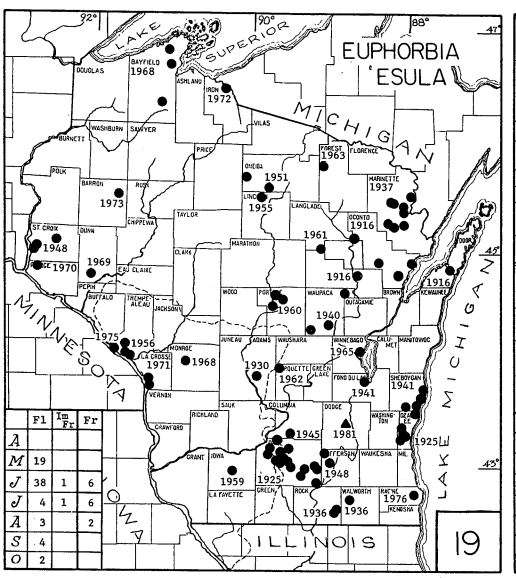
This species is extremely variable but easily recognized, and it is unlikely to be confused with any other except perhaps the sterile, narrow-leaved form of *Euphorbia esula.* Both species produce

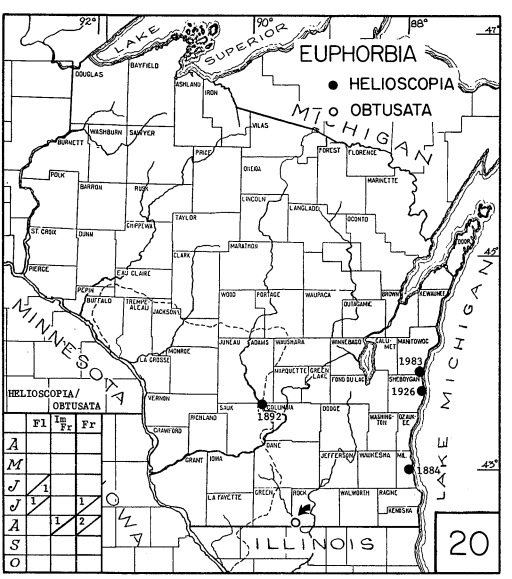
numerous erect fertile and sterile stems, often forming large colonies. The stems are tufted from a crown and scattered from buds on the rhizomes; but in *E. esula* they are taller and less crowded, and the rootstocks are deeper and more slender. In *E. cyparissias* the very numerous linear leaves are mostly less than 3 cm long and 2.5 mm wide. They are especially dense on the axillary branches, which eventually overtop the inflorescence and give the plant a bushy appearance. *E. esula* has relatively fewer, generally linear-oblanceolate leaves usually more than 3 cm long and 3 mm wide, with the axillary non-flowering branches not overtopping the original inflorescence.

6. EUPHORBIA ESULA L. Map 19, Fig. 9.
   Leafy spurge, wolf's-milk
   E. poderae Croiz. of recent annotations

Glabrous *perennial HERBS from horizontal rhizomes and deep roots.* Stems solitary or clustered, erect, 4–9 dm tall, unbranched or sparsely branched near the base, these branches usually sterile; branches below the umbel (axillary rays) usually present and fertile, sometimes numerous, particularly after damage to main shoot. *LEAVES* alternate, *broadly linear to linear-lanceolate or -oblanceolate* or broader in the whorl subtending the umbel, 3–6.5 cm long; floral leaves and bracts subtending the cyathia opposite, shorter and wider than the cauline, broadly cordate. INFLORESCENCE umbelliform, (5-) 7- to 12-rayed, each ray dichotomously branched 1–3 times. Glands of the cyathium 4 (5), lunate, greenish-brown, exappendiculate. CAPSULES 2.5–3 mm long, exserted as much as 1 cm beyond the involucre, somewhat granular-roughened on the keels. SEEDS oblong-ellipsoid, 2–2.3 mm long; *coat smooth,* orangish-brown or silver-gray to white, *typically mottled,* with a dark vertical line (raphe) extending along one side and a conspicuous flattened caruncle.

An aggressive and noxious weed, native of Eurasia, now widely established in N. Am. from Que. and N. Engl. to B.C., south to Md. and Colo., in Wisconsin a fairly recent adventive now widely





naturalized and in many areas a troublesome weed in fields, roadsides, railroads, and other disturbed ground, and an active invader of open oak woods and undisturbed prairie remnants where its extermination presents a hard-to-solve problem. It was first collected in 1916 in Oconto County by Goessl (*s.n.,* WIS). According to Fassett (1933), it was first seen at Madison in 1929, with the earliest collections from 1925 (Dane and Ozaukee cos.), 1928 (Oconto Co.), and 1930 (Adams Co.). A newspaper article from the *Delavan Republican* of July 1, 1937, noted the occurrence of *E. esula* in Wisconsin "in small patches" and stated that it was spreading rather rapidly. The roots are deep, strong, and spread vigorously (they have been traced to a depth of 15 ft. [Bakke, 1936]), making leafy spurge difficult to eradicate. Patches spread vegetatively 1 to 3 ft. per year and produce more than 200 shoots per m^2 in light soils and up to 1,000 shoots per m^2 in heavy soils (see Selleck, 1959). Flowering primarily 11 May to 2 Jul, with some flowering as late as 15 Oct; fruiting 13 Jun through October, with dispersed fruit as early as 4 Sep.

Over the past 70 years authors have held widely different opinions concerning the correct identity of the leafy spurges. Croizat (1945) claimed that the North American populations included in the "esula complex" comprise four taxa, the great majority of plants being hybrids between *E. esula* and *E. virgata* Waldst. & Kit. (*E.* X*intercedens* Podp. [1922] [non *E.* X*intercedens* Pax (1905)], *E.* X*podperae* Croiz. [1947], as well as earlier names). Both *E. virgata* and *E.* X*podperae* are closely related to, if not conspecific with, *E. esula,* and modern students of the American and European floras prefer for now to treat the entire assemblage as one species, *E. esula* L. (1753). However, natural hybrids between *E. esula* (including *E. virgata*) and *E. cyparissias* have been reported (as *E.* X*pseudo-esula* Schur) from Ontario (Moore & Frankton, 1969), and in the treatment of the genus *Euphorbia* for the Great Plains (McGregor, 1986), two distinct entities are given taxonomic recognition, *E. esula* and a presumed hybrid between *E. esula* and *E. virgata* under the epithet *E.* X*pseudovirgata* (Schur) Soo. This hybrid consistently produces cauline leaves that are only 3–5 mm wide, widest at or below the middle, and tapering toward the apex, whereas the true *E. esula* has the main stem leaves 3–10 mm wide, widest above the middle, and rounded at the apex. No segregation of Wisconsin material has been attempted on these bases.

See notes under E. *cyparissias* (no. 5).

7. EUPHORBIA OBTUSATA Pursh
Blunt-leaved spurge Map 20, Fig. 8.

Glabrous annual HERBS; stems erect, 3–7 dm tall, unbranched for most of their length. LEAVES alternate, estipulate, sessile, the *blades oblanceolate to oblong-oblanceolate or slightly pandurate,* serrulate, the upper ones subcordate and somewhat clasping at the base, those subtending the umbel similar but broader, the floral leaves and bracts subtending the cyathia broadly ovate. Primary rays of UMBEL 3 (rarely 5), sometimes branching more than once; *cyathium with* 4 or 5 *exappendiculate red or reddish- or orangish-brown* transversely elliptic *glands. CAPSULES* 2.7–3.2 mm long, *verrucose. SEEDS lenticular,* 2–2.1 mm long, dark grayish-brown, *with a smooth or obscurely reticulate surface and a papilliform caruncle.*

Occasional in the southeastern U.S. from S.C. to e. Tex., north to Pa., se. Mich. (where probably adventive), and Ia., in more or less damp rich woods (often on wooded banks of rivers and ponds), alluvial fields, and roadsides, the only Wisconsin collection from "Nelson Rd Sugar River bottom" in Rock County

(*Fell 57-404,* 10 Jun 1957 [fl], WIS). If assumed to be native rather than adventive from farther south, it is at the northern edge of the range of the species. It has been reported from along the Pecatonica and Sugar rivers in adjacent Winnebago County, Illinois (Fell, 1955). Flowering May and June; fruiting primarily in July.

8. EUPHORBIA HELIOSCOPIA L.

Map 20, Fig. 8.

Wartweed, sun spurge

Glabrous annual HERBS, the single main stem ascending, 2–5 dm tall, scarcely branched. LEAVES alternate, sessile, soon falling, 1.5–4 cm long, scale-like below, spatulate to oblong-obovate higher on the stem and obovate to broadly elliptic in the whorl below the umbel; floral leaves and bracts subtending th cyathia similar to those in the whorl, shorter but broader and often yellowish; all *leaves finely serrate,* especially at the very rounded apex. Primary *UMBEL* usually *with 5 short rays,* each forked into 3 divisions or becoming repeatedly branched on plants from rich-soil sites; *cyathia with 4 suborbicular or elliptic, brownish- or yellowish-green exappendiculate glands. CAPSULES* 2.6–3.1 mm long, *smooth. SEEDS ovoid-subglobose,* 2–2.2 mm long, *reticulate-rugose,* brown; caruncle conspicuous.

A native of Europe, widely naturalized from e. Can. to Man., south to N.Y. and Mich., and locally adventive farther south to Md. and Ill., in Wisconsin once sparingly established as an escape or adventive at the Dells of the Wisconsin River, county not specified (*Monroe 9709,* 5 Aug 1892 [fr], MIL); Milwaukee (*Hasse 744,* Jul 1884 [fl], MIL); and Sheboygan (*Goessl s.n.,* Jul 1912 [fr], WIS; *Davis s.n.,* 25 Aug 1926 [fr], WIS), now occasionally planted as an ornamental and sometimes escaped to adjacent fields and waste areas or persisting in recently abandoned gardens. No habitat information is associated with Wisconsin specimens except for the only recent one: Manitowoc Co.: Cleveland, green bean field (transmitted by *Doll s.n.,* ± 26 Aug 1983 [fr], WIS).

Acknowledgments

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