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TRANSACTIONS

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Contents

Classification of forest land into distinct units is an important area of research in the United States. In this paper Professors Trobaugh and Johnson determine 1) the variation among soil properties and ground vegetation within site units and 2) the importance of these variables in discriminating among three common site classification units in northeastern Wisconsin.

Addendum

In the 1987 Volume of *Transactions* the publication of the article entitled "The Flora of Wisconsin, Preliminary Report No. 69. Euphorbiaceae—The Spurge Family" by James W. Richardson, Derek Burch, and Theodore S. Cochrane was aided by the Norman C. Fassett Memorial Fund.

From the Editor

In Volume 75 (1987) of *Transactions,* I indicated my intention that the journal will continue to reflect the diverse interests and activities of the members of the Wisconsin Academy as well as serve as a place where original work by Wisconsin writers or about Wisconsin will be published. Articles for Volume 76 (1988) were selected with this intent, and it is hoped that the readers will enjoy both the diversity and quality. Each article has undergone careful review by outside readers as well as by a number of staff members. Rigorous professional review and editing are part of the process articles undergo prior to being presented to the readers of *Transactions.* This procedure has resulted in what I think is an outstanding issue.

Two aspects of this volume are new. Readers will remember the poem presented in the 1987 edition; in the current issue there are additional poems that represent the high quality of the work of Wisconsin poets. In addition to the poetry, there is a series of photographs by David Ford Hansen, one of Wisconsin's most talented photographers. One will quickly recognize the technical skill and the universal human emotion captured in both the poetry and the photographs. Though no definitive decision has been made, it is my hope that *Transactions* will continue to include a poetry section and photographs or a photographic essay in future volumes. Anyone wishing to submit material for the latter should contact the editor.

Two articles in this volume will be of particular interest to many readers. In 1977 The Wisconsin Department of Natural Resources (DNR) designated a group of lakes as "benchmarks." The purpose of this was to collect data in order to monitor long-term limnological conditions and changes in lakes minimally affected by human activities. The result should provide benchmarks against which to measure changes. *Transactions* is pleased to publish Professor Nichols' study of "Vegetation of Wisconsin's Benchmark Lakes" in which he describes the macrophyte vegetation found in the fourteen lakes. A second paper that will draw immediate note presents a new interpretation of the bitter strike at the Allis-Chalmers plant in West Allis, Wisconsin, in 1946–1947. Julian Stockley has reexamined the data and argues for a new interpretation of an event that still raises great emotions in many Wisconsin circles.

We at *Transactions* are pleased to present this volume of the journal to our readers. Any comment, suggestion, or submission should be addressed to the Editor.

Carl N. Haywood

Vegetation of Wisconsin's Benchmark Lakes

Stanley A. Nichols

Abstract. *This paper describes the macrophyte vegetation found in 14 benchmark Wisconsin lakes. This information forms a base to study long-term changes in the plant community when compared to future sampling efforts. A variety of limnological parameters were compared to vegetational characteristics of the benchmark lakes. Correlations between pH, alkalinity, specific conductance, free CO_2, substrate type, and acres less than 6 m and the community attributes of maximum depth of plant growth, open area in the littoral zone, diversity, and littoral zone development were tested singly and with multiple regression analysis. Not surprisingly no significant linear correlations were found. Different factors are probably responsible for determining each plant community; the dominant species in these communities often have unique adaptations to cope with environmental limitations.*

In 1977 The Wisconsin Department of Natural Resources (DNR) selected a group of lakes as benchmark lakes. The objective of the benchmark lakes program is to monitor basic limnological conditions and long-term limnological changes in lakes that are minimally affected by human activities. Changes occurring in these lakes are primarily due to natural causes, and it is assumed that changes will be much slower than in lakes that are influenced by human activities.

Besides their undisturbed nature, primary selection criteria included some assurance that neither the lake nor the associated watershed undergo significant manipulation in the future. The lakes were geographically distributed and screened for limnological characteristics so that a spectrum of lake types were represented (Fig. 1). These lakes were selected by DNR personnel; no effort was made to select the lakes randomly. Where human influence on lakes is historically significant, such as in southeastern Wisconsin, efforts were made to select the best available lakes to represent the lake types of the region.

Macrophyte sampling occurred in the lakes between 1978 and 1981. This paper reports aquatic vegetation found in the lakes during the first sampling effort. This information forms a base to study long-term community changes.

A variety of authors (Pearsall 1920;

Fig. 1. Location of benchmark lakes.

Stanley A. Nichols is a Professor of Environmental Sciences, University of Wisconsin-Extension. He is a biologist at the Wisconsin Geological and Natural History Survey, and he is associated with the Environmental Resources Center and the Department of Liberal Studies at UW-Madison. Past articles in Transactions *deal with aquatic plant resources in Wisconsin Waters.*

Spence 1972; Seddon 1972; Moyle 1945; Lind 1976; Olsen 1950; Swindale and Curtis 1957; Barko et al. 1986) found that pH, alkalinity, free CO_2, conductivity, and sediment type influenced the character of aquatic plant communities. These limnological parameters were compared to vegetational characteristics of the benchmark lakes. The objective was to better define the relationship between the aquatic environment and the aquatic vegetation, especially in light of recent information regarding the relationship of carbon to the form, function, and physiology of aquatic plants (Adams 1985).

Methods and Analysis

Depending on the importance of macrophytes in the lake, the macrophyte community was sampled annually for from one to four years. Sampling was conducted by DNR field staff of the district in which the lake occurred. This sampling generally took place during late July or August. The macrophyte sampling technique used was that of Jessen and Lound (1962). To assure geographic coverage of the lake, sampling points were selected by overlaying a grid on a lake map. Grid size and the number of sampling points per lake varied depending on the size of the lake.

At every sampling point, water depth was measured and the substrate was categorized as being hard (sand or gravel) or soft (silt, muck, or flocculent). All plant species within a 2-m diameter circle around the sample point were recorded, and a qualitative density rating was assigned to each species on the basis of the criterion established by Jessen and Lound (1962). Species unknown by the field staff were collected and sent to the Wisconsin Geological and Natural History Survey for identification or verification. They were then sent to the University of Wisconsin Herbarium as voucher specimens.

From this data a variety of floral and vegetational characteristics of the lakes was established (Table 1). The maximum depth of plant growth is the depth of the deepest sampling point where vegetation was found during all sampling periods. The open area in the littoral zone was calculated as the frequency of occurrence of sampling points with no vegetation that were found in water depths equal to or more shallow than the maximum depth of plant growth.

A species was included in the flora of a lake and thus contributed to the total taxa found in the lake if it occurred in the lake during any sampling period. The frequency of occurrence of a species was calculated as the number of occurrences of a species divided by the total number of sampling points with vegetation. Likewise average density was calculated as the sum of the density ratings for the species divided by the total number of sampling points with vegetation. The frequencies were relativized and an importance value (IV) was calculated by multiplying the relative frequency by the average density. The importance value of a species is reported if it was at least 5 in at least one lake.

The sum of the IV of a lake could vary from zero in a lake with no plants to 500 in a lake where 100% of the plants have an average density of 5. Littoral zone development was calculated by multiplying the sum of the IV by one minus the percentage of open area in the littoral zone (i.e., sum of IV [1 − percent of open area in littoral zone]). Again, this value could vary from 0 to 500. It gives a general indication of the robustness and distribution of the macrophyte community.

Diversity was calculated using the formula one minus the sum of the relative frequencies squared of the species in a lake [i.e., 1 − sum of (relative frequencies)^2]. This is a modification of Simpson's (1949) diversity index.

The mean dissimilarity per year was calculated using the dissimilarity index $1-2w/a+b$ (Bray and Curtis 1957) on species IV for each sampling period. These dissimilarities were then averaged for all sampling periods for each lake.

The values for alkalinity, pH, specific conductance, secchi disk reading, and area less than 6 m deep were obtained from DNR files. Free CO_2 was calculated using the nomogram technique found in Standard Methods (AHPA 1971) and assuming a standard temperature of 20°C and total dissolved solids equal to 0.65 times the specific conductance. The percentage of hard bottom was the frequency of sampling points with vegetation having a sand or gravel substrate. Physical and community characteristics of the lakes are presented in Table 1. Two multivariate techniques were used to display the similarities and differences of lakes based on physical factors: a Bray and Curtis (1957) ordination using a dissimilarity index of $1-2w/a+b$ and a cluster analysis using the number cruncher statistical system (Hintze 1986). The physical factors used were pH, alkalinity, conductivity, free CO_2, and percent hard bottom.

The lakes in Tables 1–3 (see end of article) are organized by the group they formed in the above ordination. Group I lakes are listed at the top or left side of a table. These lakes have low alkalinity, low pH, and low specific conductance. Group V lakes are on the right side or bottom of the tables. They are lakes with high alkalinity, high pH, and high specific conductance.

Results

Flora

Table 2 displays plant species identified for the lakes. In total 95 taxa were identified. The species richness varied from 10 species in Ennis Lake to 35 species in Anodanta and Allequash Lakes. Average species richness is 20 species per lake.

By examining the columns of Table 2, one can observe in which group or groups of lakes a species was found. Allequash and Anodanta were the two most species-rich lakes. Each lake contained 35 species. Both lakes are near neutral pH, have a moderate alkalinity and light penetration, and have a predominantly soft bottom. In addition, Allequash Lake has a large area less than 6 m deep. However, no significant linear correlation was found between species richness and specific conductance, pH, alkalinity, free CO_2, secchi disk reading, percent of quads with a hard bottom, or bottom area less than 6 m deep for the benchmark lakes.

Chara spp., *Dulichium arundinaceum, Eleocharis* spp., *Elodea canadensis, Najas flexilis, Nuphar variegatum, Potamogeton amplifolius* and *Vallisneria americana* were the taxa most frequently found. All the above mentioned species were found in 50% or more of the lakes (Table 2). All the submerged species in this group are dominant members of the plant community in one or more lakes (Table 3).

Myriophyllum spicatum and *Potamogeton crispus,* two foreign invasive species, were collected in the benchmark lakes. *M. spicatum* was found in Town Line and Devils Lakes. The author also collected *M. spicatum* from Pine Lake in Waukesha County during the summers of 1984 and 1985. Ottawa Lake was the sole location for *P. crispus.* All these lakes, except Town Line, are in southern Wisconsin where lake use is much more intense.

Community attributes and correlation with environmental factors

Correlations between alkalinity, pH, specific conductance, free CO_2, percent hard bottom, and acres less than 6 m deep and the community attributes of maximum depth of growth, open area in the littoral zone, diversity, and littoral zone development were tested singly and with multiple regression analysis. No significant linear correlations were found. It is especially surprising that there was no correlation between secchi disk reading and maximum depth of growth.

Species diversity between lakes is difficult to compare. The vegetation parameters for calculating diversity were not based on equal sampling areas. Thus, larger lakes could have a higher diversity because of the larger area sampled. This may be the case for Allequash Lake. However, Prong, Perch, Town Line, and Anodanta Lakes have a high diversity but a small littoral zone.

The above calculations only indicate that there was no significant linear correlation found between the environmental and vegetational parameters studied. The environmental influence on the vegetation and community attributes based on ordination analysis is presented later in the paper.

Community change

For all lakes except Allequash, Clear, and perhaps Moon, Ennis, and Devils, the aquatic plant communities are very stable. Cox (1969) indicates that replicate samples of the same community usually show a coefficient of similarity of 0.85 (i.e., a dissimilarity of 0.15). All lakes except those mentioned above have dissimilarity values near 0.15. Therefore, the plant communities changed very little during the years they were studied.

The difference in Clear Lake from August 1979 to August 1980 is due to a dramatic increase in *Isoetes* sp. and *Najas flexilis.* They increased in importance from 6.8 to 26.1 and 0.1 to 11.2, respectively. Both species nearly doubled the frequency of quadrats in which they were found and their average density rating.

Allequash Lake experienced a decrease in the importance of *Ceratophyllum demersum* and *Elodea canadensis* between August 1979 and August 1980. They decreased in importance from 50.5 to 17.7 and 13.6 to 4.8 respectively. The decrease was due primarily to a drop in density of growth rather than in a change in frequency.

In Moon Lake there was a decrease in growth and distribution of *Chara* sp. between late July 1979 and early August 1981. This was accompanied by an increase in growth and distribution of *Vallisneria americana.* The importance value of *Chara* sp. dropped from 34.4 to 12 and that of *V. americana* increased from 43 to 110.7 during this time period.

In Devils Lake there was a trend of gradually decreasing *Myriophyllum spicatum* importance from August 1978 to August 1981. Importance decreased from 84 to 32 during this time period. A dramatic increase in *Elodea canadensis* from 19 in August 1980 to 105 in August 1981 also occurred. This trend has changed more recently. Lillie (1986) found *Potamogeton robbinsii* to be the most important species in Devils Lake, and *M. spicatum* became more important at the expense of *E. canadensis.*

Chara sp., *Potamogeton praelongus* and *Najas flexilis* shifted in importance in Ennis Lake between August 1978 and August 1981, but no trend was apparent.

Lake communities

Table 3 displays the frequency, relative frequency, average density, and importance value of the common species in each lake. A species was retained if it had an importance value of 5 or more in any lake within its group.

By imposing an importance value criterion of 5 on the species, the number of taxa was reduced from 95 to 28. In other words, only about 29% of the taxa recorded for the lakes were very important in one or more lakes.

Vegetational relationships to ordination and clustering of physical characters

The lakes with similar environmental

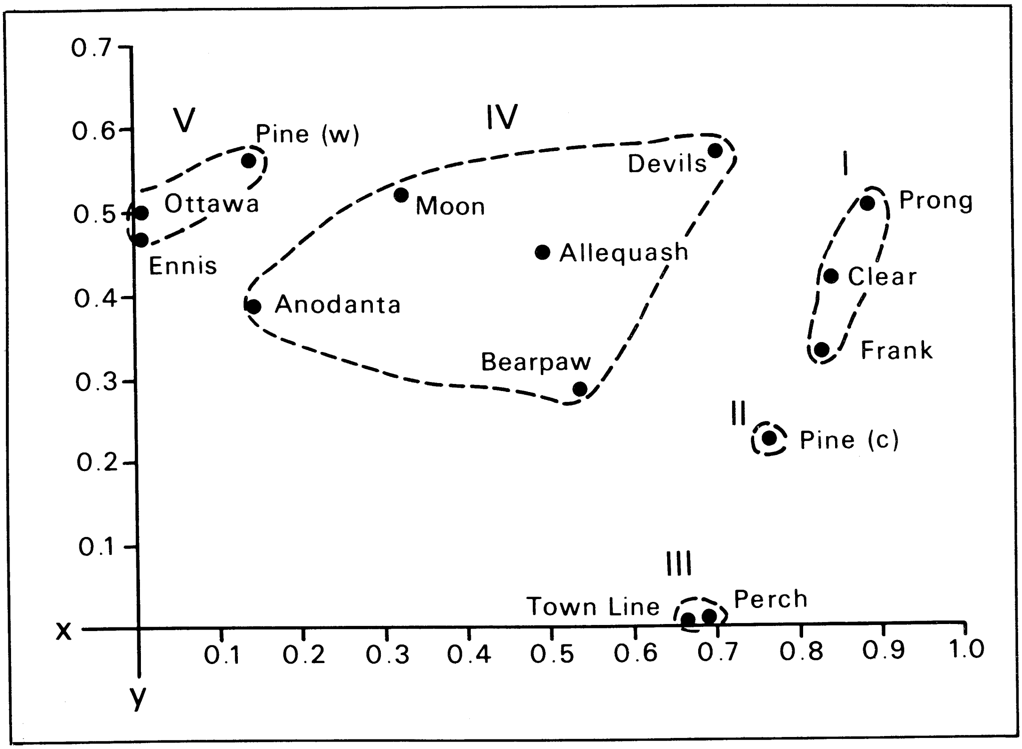

Fig. 2. Ordination of benchmark lakes based on environmental attributes.

attributes were grouped using ordination and clustering techniques. The ordination of lakes is displayed in Figure 2. The lake groups displayed in Figure 2 were determined by inspection and are therefore subjective. The groups formed display a distinct flora, vegetation, and littoral zone development. Each group has a unique assemblage of important species, the littoral zone development between the groups varies tremendously, and the highest commonality of the flora between groups is 58% (Tables 3, 4 and 5).

Cluster analysis gave slightly different results. To form five groups, clustering lumped Pine(w), Ottawa, and Ennis; Town Line and Perch; and Prong, Clear, and Frank. To this extent, clustering gave similar results as ordination. Clustering added Devils to the Prong-Clear-Frank Lake group and Pine(c) to the Perch-Town Line group, and separated Allequash-Bearpaw Lakes and Moon-Anodanta Lakes. Although the determination of groups using clustering may be more mathematically rigorous, the selection of the final number of groups is subjective, so it is probably no better or worse than the inspection technique.

The groups formed by ordination and inspection were selected as a basis for discussion in this paper. The comparison of the two methods indicates that describing plant communities found at the extremes of environmental conditions will likely be easier than describing those found in moderate conditions. For instance, Devils Lake has a floral similarity of 0.21 with Group I lakes and 0.22 with the remaining Group IV lakes. On the basis of flora, it could logically be combined with Group I, Group IV, or considered intermediate. The case for placing Pine(c) lake in Group III versus Group I

Table 4. Summary of vegetation attributes

	Group I	Group II	Group III	Group IV	Group V
Average maximum growth depth (m)	4.6	5.0	4.6	4.0	4.7
Average diversity	0.86	0.76	0.87	0.86	0.74
Average no. taxa	21	21	20	22	14
Average lit. zone development	15	16	98	47	114

on the basis of floral similarity is better (coefficient of floral similarity is 0.46 vs. 0.36), but not overwhelmingly so. A much larger data base is needed to better define plant communities in moderate environmental conditions.

Discussion and Conclusions

The benchmark lakes are only a small percentage of Wisconsin's 14,000 lakes and the taxa represented constitute less than half of the potential plants in Wisconsin's lakes (R. Read, Wisconsin DNR, personal communication). Therefore, the sampling is not necessarily representative of the variety of Wisconsin lakes and lake plants. However, interesting relationships between aquatic vegetation and habitat factors emerge even in this small group of lakes.

Group I. Lakes in Group I have low pH, alkalinity, and specific conductance, which lead to low free CO_2 and low total dissolved inorganic carbon. Low carbon availability may be the key factor explaining the vegetation and productivity of these lakes. The plant community is strongly dominated by floating leaved species such as *Brasenia schreberi* and rosette plants such as *Isoettes* spp. The stomata of *B. schreberi* occur on the upper epidermis of the floating leaf (Sculthorpe 1967). This is a useful adaptation in a carbon limited environment because atmospheric CO_2 can be utilized for photosynthesis. In other words, as Steeman-Nielsen (1944) points out, aquatic plants that have organs of assimilation above the surface of the water are not photosynthetically aquatic plants.

Some rosette plants, especially the Isoetids, can maximize the utilization of CO_2 through such mechanisms as crassulacean acid metabolism, the use of sedimentary dissolved inorganic carbon, a leaf morphometry that lowers the boundary layer resistance to CO_2 flux across the unstirred layer of water next to the leaf, and recycling of respired CO_2 (Adams 1985).

Group II. Pine Lake in Chippewa County is the lone lake in Group II. The vegetation of Pine Lake is clearly distinct from Group I or Group III lakes (Tables 4 and 5) *Potamogeton epihydrus* is the only submerged species that Groups I and II have in common. Pine Lake is not florally depauperate. However, the majority of the species are emergent or floating leaved species, including *Nymphaea tuberosa,* the only important species in the lake. Even the submerged species *Potamogeton natans, Potamogeton gramineus,* and *Potamogeton epihydrus* can have floating leaves. Again, these species have their organs of assimilation out of the water so they are not totally dependent on the water to obtain their resources. However, water depth limits the potential habitat they can occupy.

No submerged species are important in this lake. More recent water chemistry data indicate a higher pH and lower alkalinities than those reported in Table 1 (pH 6.6–7.0, total alkalinity 6.0–8.0). These data would slightly shift the location of Pine Lake in the ordination; however, they better explain the vegetation pattern. There is no development of acidophilous flora (Wetzel 1984) and free CO_2 would be much more limited.

Group III. The vegetation in the Group III lakes is typical of a bog lake. The alkalinity, specific conductance, and pH of the lakes are low but the littoral zone development is high. The primary habitat difference between Group III lakes and Group I and II lakes appears to be that Group III lake bottoms consist primarily of soft sediments.

The adaptation of the floating leaves of *B. schreberi* and *N. odorata* for living in a carbon-poor environment has been discussed previously. The genus *Utricularia* also has some interesting adaptations. Many members of this genus are submerged and free floating. They have a large surface area because of their finely dissected leaves, which allows them to absorb nutrients over their whole surface. This may give them an advantage in obtaining nutrients and carbon from a nutrient-poor environment or obtaining nutrients and carbon from rich organic sediments (Wetzel et al. 1985). Many *Utricularia* are carnivorous. Aquatic animals caught in the traps of these carnivores are probably a significant source of phosphorus, nitrogen, and perhaps some minor elements (Hutchinson 1975).

Group IV. The mesic lakes are contained in Group IV. Alkalinities are higher in Group IV lakes than they are in Groups I, II, or III lakes. Therefore, dissolved inorganic carbon conditions are more favorable for the growth of submerged species. All the important species except *Nuphar advena* are submerged species. Species in this group, such as *Elodea canadensis* and *Myriophyllum spicatum,* have the ability to use bicarbonate as a carbon source for photosynthesis (Nichols and Shaw 1986). This is an advantage in lakes where alkalinities are moderate to high, but where high pH limits the free CO_2. Group IV represents a large and diverse group of lakes. As mentioned previously, subgroups could probably be defined with a larger sampling of this lake group.

Table 5. Floral similarity of lake groups

	I	*II*	*III*	*IV*	*V*
I	1.00				
II	0.36	1.00			
III	0.40	0.46	1.00		
IV	0.51	0.34	0.58	1.00	
V	0.35	0.28	0.34	0.42	1.00
Mean Similarity	0.41	0.36	0.45	0.46	0.35

Group V. The hard-water lakes of Group V typically have a high alkalinity, high pH, and high specific conductance. They also are low in free CO_2. Species that are predominant in these lakes need bicarbonate to photosynthesize effectively. The data indicate that *Chara* is the most successful species under these conditions. Little was found in the literature about the ability of *Chara* to use bicarbonate. Wetzel (1960) suggests the large surface area of *Chara* aids carbon uptake and that some algal species can utilize bicarbonate ion faster than higher plants because the chloroplasts are much closer to the carbon source. Carbon need not be transported as far as is the case with vascular hydrophytes, so there is less resistance to carbon flux from the environment to the chloroplast. These two factors could explain the dominance of *Chara* under the conditions found in Group V lakes. However, Maberly and

Spence (1983) rated *Chara* sp. much lower in its ability to extract inorganic carbon from the water than *M. spicatum,* and somewhat similar in ability to *P. crispus* and *E. canadensis.*

Chara is interesting because it is a widespread species, but becomes dominant only in the hard-water lakes. In other lakes *Chara* and *Najas flexilis* act as early successional species and are readily replaced by other macrophytes (Nichols 1984; Engel and Nichols 1984). This does not appear to be the case in Group V lakes.

Wetzel (1966) states that low productivity is characteristic of this lake type. This is not inconsistent with the fact that these lakes have the highest littoral zone development. Littoral zone development refers more to the area the plants occupy rather than their productivity. *Chara* spp. and *Najas flexilis* are often small in stature and do not produce a lot of structural material. They can occupy a large area without being productive.

It is interesting to note that *Najas flexilis, Ceratophyllum demersum, Elodea canadensis, Myriophyllum spicatum* and *Vallisneria americana* displayed dramatic population shifts in the lakes during the course of the study. These species often cause aquatic nuisance problems in lakes (Trudeau 1982). These data indicate that these species are naturally dynamic and can therefore rapidly take advantage of plant population shifts in a lake. In a lake where a perturbation occurs, these species may readily be able to take advantage of the situation and become dominant.

In summary, this study supports the observations of other authors cited in the introduction that pH, alkalinity, specific conductance, free CO_2, and substrate type are important in determining the plant community and plant distributions in lakes. It is not surprising that there is a lack of linear correlations between these factors and vegetational characteristics. Different factors are probably responsible for determining each plant community, and the dominant species in these communities often have unique adaptations to cope with environmental limitations.

Acknowledgments

The Wisconsin Department of Natural Resources is acknowledged for providing access to the benchmark lake files. The benchmark lake files that contain all the original quadrat data and lake distribution maps are archived in the Office of Inland Lake Renewal. Michael Adams, Sandy Engel, and James Vennie are gratefully acknowledged for critically reviewing the manuscript.

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Table 1. Physical and community characteristics of the benchmark lakes.

Lake	*County*	*Total alkalinity mg/1 $CaCO_3$*	*pH*	*Specific conductance umhos /cm 25°C*	*Free CO_2 mg/1*	*Hard bottom (%)*	*Secchi (m)*	*Acres <6 m*	*Total Taxa*	*Maximum depth growth (m)*	*Open litt (%)*	*Diversity*	*Littoral zone development*	*Mean dissimilarity /year*
Prong	Vilas	5	6.6	20	2.4	83	4.5	16	24	5.1	68%	0.90	20	0.18
Frank	Vilas	10	7.1	29	1.5	54	3.1	127	14	5.1	68%	0.86	7	ND*
Clear	Oneida	10	6.8	27	3.0	73	5.9	94	26	3.6	35%	0.81	17	0.70
Pine(c)	Chippewa	17	5.8	26	32.0	42	4.6	66	21	5.0	69%	0.76	16	0.20
Perch	Bayfield	8	6.0	28	15.0	9	3.1	39	19	5.1	14%	0.86	107	0.16
Town Line	Chippewa	9	6.0	35	16.0	6	1.3	41	20	4.0	37%	0.88	88	0.14
Bearpaw	Oconto	21	6.8	71	6.5	7	3.1	149	15	3.0	65%	0.80	30	0.17
Devils	Sauk	21	7.2	85	2.6	87	5.2	94	12	3.6	35%	0.81	79	0.23
Allequash	Vilas	39	7.8	87	1.4	21	3.1	320	35	4.8	63%	0.92	26	0.47
Moon	Marinette	79	6.8	200	22.0	48	4.4	82	13	4.8	46%	0.82	52	0.27
Anodanta	Bayfield	90	6.8	238	26.0	9	2.5	22	35	3.9	42%	0.94	47	0.16
Pine(w)	Waukesha	139	8.5	360	0.8	45	3.3	141	11	5.4	41%	0.65	97	0.17
Ennis	Marquette	201	8.2	339	2.2	2	1.7	21	10	3.6	13%	0.80	112	0.23
Ottawa	Waukesha	265	7.8	471	6.2	17	2.3	28	20	5.1	23%	0.78	132	0.15

* No Data

Table 2. Flora of the benchmark lakes.

	Prong	Frank	Clear	Pine (c)	Perch	Town Line	Bear-paw	Devils	Alle-quash	Moon	Ano-danta	Pine (w)	Ennis	Ot-tawa	Occurrence (%)
Brasenia schreberi	1	0	0	1	1	1	0	0	1	0	0	0	0	0	36
Calla palustris	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7
Carex spp.	1	1	1	0	0	0	1	0	0	0	0	0	0	1	36
Ceratophyllum demersum	0	0	0	0	1	0	0	1	1	0	1	1	0	0	36
Ceratophyllum echinatum	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7
Chara spp.	1	1	1	0	0	0	0	1	1	1	1	1	1	1	71
Dulichium arundinaceum	1	1	1	1	1	1	1	0	0	0	0	0	0	0	50
Elatine minima	1	0	1	0	0	0	0	0	0	0	0	0	0	0	14
Elatine sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7
Eleocharis acicularis	1	0	1	1	1	0	0	0	0	0	0	0	0	0	29
Eleocharis palustris	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7
Eleocharis spp.	0	0	1	1	0	1	1	0	1	0	1	0	0	1	50
Elodea canadensis	0	0	1	0	0	0	1	1	1	1	1	0	1	0	50
Equisetum fluviatile	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
Eriocaulon septangulare	1	0	1	0	1	0	1	0	0	0	1	0	0	0	36
Glyceria canadensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Glyceria spp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	14
Gratiola aurea	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Heteranthera dubia	0	0	0	0	0	0	0	0	1	1	1	0	0	0	21
Iris versicolor	0	1	0	1	0	0	0	0	0	0	0	0	0	0	14
Isoetes echinospora	0	1	0	0	1	0	0	1	0	0	0	0	0	0	21
Isoetes macrospora	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Isoetes spp.	0	0	1	0	0	0	0	0	1	0	0	0	0	0	14
Juncus spp.	0	0	1	1	1	0	1	0	0	1	0	0	0	0	36
Lemna minor	0	0	0	0	1	0	0	0	1	0	1	0	0	0	21
Lemna trisulca	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7
Lobelia dortmanna	1	0	1	0	0	0	0	0	0	0	0	0	0	0	14
Megalodonta beckii	0	0	0	0	0	0	0	0	1	0	1	0	0	0	14
Myriophyllum exalbescens	0	0	1	0	0	0	0	0	1	0	0	0	0	0	14
Myriophyllum farwellii	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
Myriophyllum spicatum	0	0	0	0	0	1	0	1	0	0	0	0	0	0	14
Myriophyllum tenellum	1	0	1	0	0	0	0	0	0	0	0	0	0	0	14
Myriophyllum verticillatum	0	0	0	0	0	0	0	0	0	0	1	0	1	0	14

Table 2. Flora of the benchmark lakes.—Continued

	Prong	Frank	Clear	Pine (c)	Perch	Town Line	Bear-paw	Devils	Alle-quash	Moon	Ano-danta	Pine (w)	Ennis	Ot-tawa	Occurrence (%)
Myriophyllum spp.	0	0	0	0	0	0	0	0	0	0	0	1	0	1	14
Najas flexilis	0	1	1	0	0	0	1	0	1	1	0	0	1	1	57
Najas gracillima	0	0	1	0	0	0	0	0	0	0	1	0	0	0	7
Najas guadalupensis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7
Najas marina	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7
Najas sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Nitella spp.	0	1	1	0	0	1	0	1	0	0	1	0	0	1	43
Nuphar advena	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7
Nuphar variegatum	0	1	1	1	0	1	0	0	1	0	0	1	1	1	57
Nuphar spp.	0	0	0	0	1	0	0	0	1	0	1	0	0	1	29
Nymphaea odorata	1	1	0	1	0	1	0	0	1	0	0	1	0	0	43
Nymphaea tuberosa	1	0	0	0	0	0	1	0	0	0	1	0	0	0	21
Nymphaea sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7
Polygonum amphibium	1	0	0	0	0	1	0	0	0	0	0	0	0	0	14
Pontederia cordata	0	1	0	1	0	0	0	0	0	0	1	0	0	0	21
Potamogeton amplifolius	0	0	1	0	0	1	1	1	1	1	1	1	1	1	71
Potamogeton crispus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7
Potamogeton diversifolius	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7
Potamogeton epihydrus	1	0	0	1	1	1	0	0	0	0	1	0	0	0	36
Potamogeton gramineus	0	0	0	1	0	1	1	1	1	1	0	0	0	0	43
Potamogeton illinoensis	0	0	0	0	0	0	0	1	0	0	0	1	0	1	21
Potamogeton natans	0	0	0	1	0	1	1	0	0	0	1	0	1	0	36
Potamogeton nodosus	1	0	0	0	0	0	0	0	0	0	0	1	0	0	14
Potamogeton oakesianus	0	0	0	0	1	0	0	0	1	0	0	0	0	0	14
Potamogeton obtusifolius	0	0	0	0	0	0	0	0	1	0	1	0	0	0	14
Potamogeton pectinatus	0	0	0	0	0	0	0	0	0	0	0	1	0	1	14
Potamogeton praelongus	0	0	0	0	0	0	0	1	1	0	1	0	1	0	29
Potamogeton pusillus	0	0	1	0	0	1	0	0	0	1	1	0	0	0	29
Potamogeton richardsonii	0	0	0	0	0	0	0	0	1	1	1	0	0	0	21
Potamogeton robbinsii	1	0	0	0	0	0	0	1	1	1	1	0	0	0	36
Potamogeton spirillus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Potamogeton strictifolius	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7
Potamogeton vaginatus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7

Table 2. Flora of the benchmark lakes.—Continued

	Prong	Frank	Clear	Pine (c)	Perch	Town Line	Bear-paw	Devils	Alle-quash	Moon	Ano-danta	Pine (w)	Ennis	Ot-tawa	Occurrence (%)
Potamogeton vaseyi	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7
Potamogeton zosteriformes	0	0	0	0	0	0	0	0	1	1	1	0	0	0	21
Potamogeton spp.	1	0	0	1	0	0	0	0	0	0	0	1	0	1	29
Potentilla palustris	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7
Ranunculus reptans	1	0	1	0	0	0	0	0	0	0	0	0	0	0	14
Ranunculus trichophyllus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7
Ranunculus sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Sagittaria graminea	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7
Sagittaria latifolia	0	0	0	1	1	1	1	0	1	0	0	0	0	0	36
Sagittaria rigida	0	1	0	0	0	1	0	0	1	0	0	0	0	0	21
Sagittaria spp.	1	1	1	1	0	0	0	0	1	0	1	0	0	0	43
Scirpus americanus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7
Scripus cyperinus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7
Scirpus validus	0	0	0	1	1	0	0	0	1	0	1	0	0	1	36
Scirpus spp.	0	0	0	0	0	0	0	0	0	0	1	0	1	1	21
Sparganium angustifolium	0	0	0	0	1	0	0	0	1	0	0	0	0	0	14
Sparganium chlorocarpum	0	0	0	0	0	1	0	0	0	0	1	0	0	0	14
Sparganium fluctuans	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
Sparganium spp.	0	0	1	0	0	0	0	0	0	0	1	0	0	0	14
Spirodela polyrhiza	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7
Typha latifolia	0	0	0	1	0	1	1	0	0	0	1	0	0	1	36
Utricularia geminiscapa	1	0	0	0	0	0	0	0	0	0	1	0	0	0	14
Utricularia gibba	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
Utricularia intermedia	0	0	0	0	1	0	0	0	1	0	0	0	0	0	14
Utricularia vulgaris	0	0	0	0	0	1	0	0	1	0	0	0	0	0	14
Utricularia spp.	1	0	0	0	0	0	0	0	1	0	1	0	0	1	29
Vallisneria americana	1	0	0	0	0	1	0	1	1	1	1	0	0	1	50
Zanichellia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7
Zizania aquatica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7
Taxa per lake	24	14	26	21	19	20	15	13	35	13	35	11	10	20	

Table 3. Community attributes in benchmark lakes.*

Group I Lakes	Prong Lake				Frank Lake				Clear Lake			
Scientific Name	*Freq**	*Rfreq***	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*
Brasenia schreberi	51.13	19.49	1.56	30.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Isoetes macrospora	31.58	12.04	0.92	11.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagittaria spp.	32.33	12.32	0.82	10.10	25.00	16.67	0.38	6.33	8.21	5.37	0.19	1.02
Nymphaea tuberosa	25.56	9.74	0.62	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nymphaea odorata	21.80	8.31	0.57	4.74	4.17	2.78	0.04	0.11	0.00	0.00	0.00	0.00
Chara spp.	3.76	1.43	0.11	0.16	41.67	27.78	0.46	12.78	11.94	7.80	0.43	3.35
Isoetes spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.10	19.02	0.86	16.36

Group II and III Lakes	Pine(C) Lake				Perch Lake				Town Line Lake			
Scientific Name	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*
Nymphaea odorata	65.85	45.25	1.07	48.42	0.00	0.00	0.00	0.00	84.87	19.49	2.84	55.35
Brasenia schreberi	10.57	7.26	0.22	1.60	50.34	16.19	1.72	27.85	69.74	16.01	2.05	32.82
Myriophyllum farwellii	0.00	0.00	0.00	0.00	66.67	21.45	1.78	38.18	0.00	0.00	0.00	0.00
Utricularia gibba	0.00	0.00	0.00	0.00	63.27	20.35	1.85	37.65	0.00	0.00	0.00	0.00
Utricularia intermedia	0.00	0.00	0.00	0.00	48.30	15.54	1.31	20.36	0.00	0.00	0.00	0.00
Utricularia vulgaris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.95	18.13	2.44	44.24
Potamogeton pusillus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.87	8.01	0.86	6.89

Group IV Lakes	Bearpaw Lake				Devils Lake				Allequash Lake			
Scientific Name	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*
Nuphar advena	56.00	33.14	1.67	55.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potamogeton amplifolius	43.00	25.44	0.91	23.15	3.17	1.54	0.09	0.14	20.00	5.76	0.50	2.88
Nymphaea tuberosa	21.00	12.43	0.48	5.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chara spp.	0.00	0.00	0.00	0.00	4.52	2.20	0.06	0.13	14.81	4.26	0.49	2.09
Potamogeton pusillus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myriophyllum spicatum	0.00	0.00	0.00	0.00	54.30	26.43	1.87	49.42	0.00	0.00	0.00	0.00
Potamogeton robbinsii	0.00	0.00	0.00	0.00	49.77	24.23	1.55	37.56	35.56	10.24	0.91	9.32
Elodea canadensis	4.00	2.37	0.09	0.21	45.70	22.25	1.51	33.60	34.81	10.02	0.92	9.22
Ceratophyllum demersum	0.00	0.00	0.00	0.00	9.50	4.62	0.11	0.51	62.96	18.13	1.90	34.45
Zizania aquatica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.63	8.53	0.99	8.44
Vallisneria americana	0.00	0.00	0.00	0.00	8.60	4.19	0.21	0.88	11.85	3.41	0.19	0.65
Myriophyllum verticillatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nuphar spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lemna trisulca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Group IV Lakes (Cont.)

	Moon Lake				Anadonta Lake			
Scientific Name	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*
Nuphar advena	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potamogeton amplifolius	15.07	7.97	0.37	2.95	16.44	2.54	0.34	0.86
Nymphaea tuberosa	0.00	0.00	0.00	0.00	43.11	6.67	1.18	7.87
Chara spp.	30.36	20.29	1.22	24.75	1.78	0.28	0.04	0.01
Potamogeton pusillus	15.07	7.97	0.30	2.39	36.00	5.57	0.94	5.24
Myriophyllum spicatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potamogeton robbinsii	4.11	2.17	0.05	0.11	5.33	0.82	0.08	0.07
Elodea canadensis	10.96	5.80	0.12	0.70	14.67	2.27	0.26	0.59
Ceratophyllum demersum	0.00	0.00	0.00	0.00	78.67	12.17	2.20	26.77
Zizania aquatica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vallisneria americana	61.64	32.61	1.99	64.89	5.78	0.89	0.11	0.10
Myriophyllum verticillatum	0.00	0.00	0.00	0.00	66.22	10.24	1.69	17.31
Nuphar spp.	0.00	0.00	0.00	0.00	52.44	8.11	1.47	11.92
Lemna trisulca	0.00	0.00	0.00	0.00	45.78	7.08	0.72	5.10

Group V Lakes	Pine (W) Lake				Ennis Lake				Ottawa Lake			
Scientific Name	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*	*Freq*	*Rfreq*	*Aden*	*IV*
Myriophyllum spp.	66.10	50.99	2.58	131.55	0.00	0.00	0.00	0.00	11.87	5.68	0.24	1.36
Chara spp.	35.59	27.45	1.16	31.84	48.64	20.64	1.58	32.61	83.98	40.20	3.25	130.65
Najas flexilis	0.00	0.00	0.00	0.00	57.14	24.24	1.90	46.06	4.75	2.27	0.10	0.23
Potamogeton praelongus	0.00	0.00	0.00	0.00	54.76	23.23	1.64	38.10	0.00	0.00	0.00	0.00
Nuphar variegatum	1.69	1.30	0.04	0.05	31.29	13.28	0.78	10.36	3.86	1.85	0.08	0.15
Scirpus validus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.77	22.87	1.68	38.42

* freq—frequency; rfreq—relative frequency; aden—average density; IV—importance value
**relative frequencies will not add up to 100% because of deleted species

"Red Purge": The 1946–1947 Strike at Allis-Chalmers

Julian L. Stockley

In 1947, Harold Story, Allis-Chalmers' labor policy engineer and attorney, addressed a convention of the National Association of Manufacturers in New York. He told his audience that, during the 1946–1947 strike at Allis-Chalmers' plant at West Allis, Wisconsin, the company had finally been able to expose what he called the Communist leadership of Local 248:

> Until recently, public opinion has blindly and wholeheartedly supported unionism and collective bargaining. . . .
>
> . . . During Allis-Chalmers' last strike, public opinion changed. Only then was Allis-Chalmers in a position to tell its employees . . . [about] the devastating destructiveness of Communist union leadership in the labor movement.[1]

Story then described how Allis-Chalmers, manufacturers of heavy machinery and farm equipment, had used this shift in public opinion to win the eleven-month strike and break the union. Instead of negotiating the disputed contractual issues that would determine who would control the shop floor and employee loyalty, Allis-Chalmers' management mounted a press campaign against the alleged Communists among Local 248's most active membership. In this way, management sidestepped the contractual points of contention and focused public attention on what they labeled the Communist infiltration in Local 248. Until recently the assertion that Local 248 was Communist dominated has been popularly accepted. But a careful study of the evidence indicates that the charges are unproven and that the company only used them to avoid negotiating a legitimate contractual agreement. It was thus that Allis-Chalmers won the strike and broke the union, dismissed over ninety of the local's most active union members, and forced an unprecedented turnover in Local 248's leadership.

The company found support for its position in the emerging national anti-labor attitude, reflected in and fostered by the local and national press, and in the development of a postwar Red Scare. Allis-Chalmers was also convinced that it had relinquished too much managerial control to Local 248 in the decade before the 1946–1947 strike. From 1936–1946, while the local was building its membership and hoping to gain union securities comparable to those won by like brotherhoods, relations between Allis-Chalmers and Local 248 were strained. The company viewed the 1946–1947 strike as an opportunity for a final showdown.

In 1946 when Local 248 members walked out in the hope of securing wages comparable to national industrial wage rates, an improved grievance procedure, and union security, Allis-Chalmers' management was unwilling to address these contractual points or negotiate a compromise. Local 248 not only had to withstand Allis-Chalmers' managerial pressure, changes in national attitudes, and the press campaign orchestrated by the company, but also had to conduct its strike with reserved support from the leaders of its international, the United Automobile Workers (UAW), and the Congress of Industrial Organizations (CIO) of which the UAW was a member.

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After World War II, the UAW underwent an administrative shift. Its rising leader, Walter Reuther, used the public's perception of a Communist threat to gain the UAW presidency and purge the organization of alleged Communists. The CIO's president, Philip Murray, also employed the Communist issue to purge the federation's ranks. At the same time, the American public was following the House Committee on Un-American Activities' investigations of Communism in labor unions in the United States. It was in this setting that Local 248 attempted to wrest a contract from Allis-Chalmers. After an eleven-month strike, Local 248 was forced to capitulate; employees returned to work without a contract, while the company dismissed Local 248's most active members.

Local 248 was founded in the late 1930s, amid the growing tide of industrial unionism. Up until this time, Allis-Chalmers' West Allis plant had remained unorganized except for a modest membership among the company's selective craft unions, which excluded assembly-line workers. From October 1936 to January 1937, Allis-Chalmers' Federal Labor Union (FLU) 20136, affiliated with the American Federation of Labor (AFL), was under the leadership of Harold Christoffel. During this brief period, members of Allis-Chalmers' AFL trade and craft unions deserted wholesale to the Federal Labor Union, so that by January 1937 the local's membership exceeded 2,000 in a plant of approximately 8,000 employees. Because the newly created Federal Labor Union derived its membership from the assembly-line workers as well as the plant's skilled craftsmen, it came into conflict with the Federated Trade Council in Milwaukee. In March 1937, Allis-Chalmers' FLU 20136 decided to join the newly chartered CIO to become Local 248 UAW-CIO. As an affiliate of the CIO, Local 248 was no longer required to heed craft-union lines while organizing, which allowed for greater growth and flexibility in its intensive organizational program.

The greatest challenge for the new local was Allis-Chalmers' traditional anti-labor stance: Allis-Chalmers had a strike in 1906 and another in 1916, both of which "were crushed by the Company and resulted in the total destruction of the unions."[2] After the implementation of the National Industrial Recovery Act in 1933, the company set up a paternalistic, company-dominated union, the Allis-Chalmers Works Council, which existed from 1933 to 1937 and seated only Allis-Chalmers' most conservative employees. But the council functioned as a grievance board and never held contractual relations with Allis-Chalmers.

Even in the late 1930s, when other firms were moving to open labor-management communications, Allis-Chalmers' management pursued a markedly inflexible labor policy. The firm's executives continued to voice opinions that questioned or rejected labor's role in areas they considered to be under managerial authority, balked at the idea of a closed shop, and opposed any measure that legitimized union authority on the shop floor. Bert Cochran, author of *Labor and Communism,* notes a discrepancy between the company's statements and actions:

> The company maintained that it sincerely accepted collective bargaining, and was pledged to a hands-off policy in the union's internal affairs. Outside observers concluded that it was not the disinterested bystander that it pretended to be. Dr. John Steelman, head of the U.S. Labor Department Conciliation Service, was of the opinion that Max Babb, the company president, was hostile to unions, and in order to keep the CIO off balance, encouraged AFL craft organizations to come into his plants.[3]

It was in this environment that Local 248 attempted to gain recognition as the employees' contractual bargaining agent and won its first nonexclusive contract with the firm in March 1937. After the local won a National Labor Relations Board election in January 1938, Local 248 became the bargaining agent for the employees at the West Allis works.

During the close of the 1930s, the union signed relatively weak contracts compared to the contracts being signed by other UAW locals. Although recognized as the workers' bargaining agent, Local 248 still did not enjoy union security, freedom from management's arbitrariness, or a wage package comparable to those paid by area manufacturers. The contract did not provide a maintenance-of-membership clause to protect the union from membership desertion, nor did the firm dissuade AFL brotherhoods from organizing in the West Allis plant. Allis-Chalmers only agreed to remain "neutral" on the union issue, neither challenging the local directly nor aiding it in securing members. The contracts of the late 1930s also failed to free workers from Allis-Chalmers' arbitrary managerial controls. The company's shop foremen still maintained control over the write-up of employees' grievances, and management retained control over employee dismissals. Nonetheless, this period marked a limited shift in the balance of power on the shop floor at the West Allis works.

The lack of real union security remained a pressing concern for the leadership of Local 248 and was the cause of a seventy-six–day strike in 1941, which was characterized by the national press as a political strike called by the "Communist" leadership of Local 248. However, according to Stephen Meyer, the strike in fact had "all the earmarks of a standard union battle" and was actually called because Allis-Chalmers had been encouraging the AFL to organize in the West Allis works, thus challenging the CIO's Local 248 on the issue of union security.[4] The strike was settled only after the federal government intervened. The issues focused on the labor-management conflict over shop, production, and worker control; yet, more important than this, the 1941 strike introduced the public to and provided the firm with publicized allegations of the Communist Party's influence in Local 248.

During World War II, the labor-management conflict over authority on the shop floor continued as Local 248 attempted to gain recognition as an autonomous power from the company. By using the grievance procedure provided in the contract and taking advantage of the nonpartisan referee assigned to judge these cases, Local 248 was able to modify some contractual boundaries, increase its influence in the shop, and gain a limited amount of managerial authority in the West Allis plant. Had the "Communist" leadership of Local 248 been heeding the advice of such leading Communist figures as Earl Browder, the union would have curtailed its use of the grievance procedure and listened to Browder's urging that "Communists must avoid alienating employers" in order to maximize wartime production. Instead, the local's leadership

> . . . ignored the Party's admonitions to cooperate with management to increase production. Grievances were magnified and, although both union and management had long approved incentive pay, the union stubbornly refused to have it applied to the brass foundry. It also opposed the fifty-six–hour week that the navy had requested to speed up production on navy orders.[5]

Local 248 refused to relent in its struggle for union security, recognition as a legitimate shop power, and economic gains on behalf of its membership. The war afforded the union one gain. In 1943, after the National War Labor Board was called in, Allis-Chalmers was forced to put a maintenance-of-membership clause in the new contract. By guaranteeing that dues-paying members had to maintain paid membership and could not leave the union once they joined, Local 248 was awarded its first contractual clause granting relative union security. The company refused to renew this clause during postwar contractual negotiations.

Wartime relations between Local 248 and Allis-Chalmers were strained, and quite often government agents had to be called in to resolve the contractual disputes of previous years. In the spring of 1946, the local was still negotiating for a contract, which had been under discussion since April 1944 when the previous contract had expired; West Allis employees had been working under the old contract since that time. During the negotiations, Allis-Chalmers ignored the suggested bargaining concessions that the War Labor Board and the Federal Conciliation Service recommended and also ended the referee system that had been used to settle grievances during the war. In an additional show of strength, the company decided to adhere "to its traditional policy which stated that 'no employee's job at Allis-Chalmers shall depend on membership in the Union,'" to its stand on tightening grievance procedures, and to its final wage offer, which was five cents below the national pattern.[6]

As labor-management tensions were nearing strike porportions at its West Allis home plant in the spring of 1946, Allis-Chalmers also faced conflicts with seven out of its eight plants nationwide. By 30 April 1946, Allis-Chalmers had four plants on strike: LaPorte, Indiana; Springfield, Illinois; Norwood, Ohio; and Pittsburgh, Pennsylvania. Three more of its plants went on strike that day: Boston, Massachusetts; LaCrosse, Wisconsin; and West Allis, Wisconsin. Since late 1945, union representatives from various Allis-Chalmers' plants had been meeting with the hope of drawing up a master contract that would cover all of the company's plants. Had Allis-Chalmers accepted the unions' offer to bargain on this scale, the company would have been recognizing the unions as legtitimate, autonomous bargaining partners. But management rejected this idea because it interfered with the company's belief in a fundamental managerial right—the right to decide the terms of the contract offered. After the strike began and as individual unions were forced to settle, Allis-Chalmers sister unions maintained contact through letters, encouraging the locals still out to hold the strike fronts.

Allis-Chalmers also refused Local 248's offer of arbitration because, as Ozanne has observed,

> the party which feels stronger and is anxious to gain something by its power which it fears it might not get from an arbitrator will, of course, refuse arbitration.[7]

Allis-Chalmers was ready for a showdown with the unions that challenged its managerial prerogatives, and the company was especially keen on confrontation with Local 248. As has been pointed out, in its home plant of West Allis, the company evaded the main points of contention: wages, grievance procedures, and union security. Instead, Allis-Chalmers launched a propaganda drive aimed at persuading the public and its West Allis employees that the leadership of Local 248 and its strike were actually a "Communist-inspired plot to disrupt American industry" and that Local 248's "Communist" leadership did not have the workers' best interest at heart.[8]

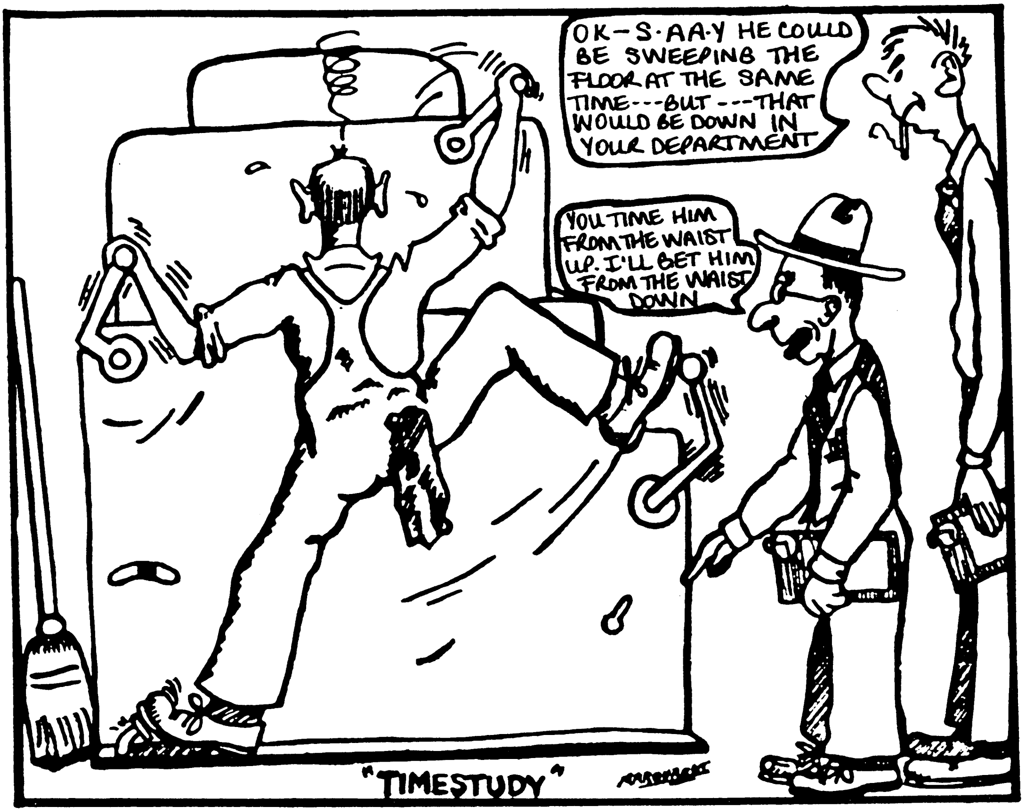
When Allis-Chalmers readied its public relations campaign against Local 248 in 1946, it was addressing a public that had become increasingly concerned about the "Red Bogey" in America, to use David M. Oshinsky's terminology.[9] From the perspective of most American citizens, there seemed to be good reason for alarm over the new "Red menace." While the press highlighted news of Stalin's increasing boldness in Eastern Europe, and of the Canadians exposing a Soviet spy ring, the Truman Administration fueled the nation's frenetic agitation by gearing up for cold war with the newly emerging Soviet enemy. The American people seemed to conclude that although they could not control threats from the outside, they could at least identify and eliminate the enemy within their own ranks.

In 1946, the nation elected the first Republican Congress in eighteen years. Republicans championed the anti-Communist cause, an issue with voter appeal. Lawrence S. Wittner has suggested that American businessmen were the Republican's "keenest supporters" and that they were still "smarting from a generation of social criticism by journalists, news commentators, labor leaders, artists, and intellectuals." In 1946 and 1947, the United States Chamber of Commerce felt the internal Communist threat so keenly that it published the pamphlets "Communist Infiltration in the United States: Its Nature and How to Combat It," "Communists in the Government, The Facts and a Program," and "Communists within the Labor Movement, Facts and Countermeasures." In 1947, the same group put forward the idea that the Justice Department should make public "at least twice a year a certified list of Communist-controlled front organizations and labor unions." The postwar labor strikes foundered under the suspicious eyes of the American public.[10]

During the postwar period, labor unions, many of which had benefited from the organizational skill and commitment of Communist activists, became targets for press "exposures" and Congressional hearings. Under Franklin D. Roosevelt's tutelage ten years earlier, the public explored the possibilities of a cooperative marriage between labor and management as one means of curing depression ills. After the war, however, the public was less willing than it had been during the late 1930s to view labor's courtship in a positive light and often felt as though it had been duped by Communist labor leaders. Sometimes business leaders, organizations, various presses (including the influential Hearst syndicate), and Congressional committees undertook to further their own interests by labeling and exposing the "un-American" elements at the forefront of the American labor movement and by crusading against Communist subversion and subversives. After the 1946–1947 strike at the West Allis plant, Allis-Chalmers' management took pride in its "battle scar" and victory over the union—with the help of the local and national press and two congressional committees—because the company chose "battle with a Communist-dominated union rather than appeasement."[11]

Although Walter Geist, Allis-Chalmers' president, maintained that the "fight was the result of Communist infiltration," he also admitted that the conflict "was to determine whether the company or the union was to run our shops."[12] When the negotiations ended in late April of 1946, the *Wisconsin CIO News: Local 248 Edition* cited ten issues still under contention: discrimination, union security, pay rate, grievance procedure, discipline, layoff, layoff in lieu of transfer, transfers, seniority, and press statements. The three issues that were paramount to the local were the clauses governing union security, grievance procedures, and wages. Each of these was indirectly and directly concerned with shop control. Unable to reach an agreement on any of these issues, and after a strike vote of 8,091 to 251 on 29 April 1946, employees at the West Allis plant walked out.

When the strike began at the West Allis works, both the company and the local, anticipating a final power contest, mo-



From the Wisconsin CIO News: Local 248 Edition, *5 April 1946, p. 8*

bilized their forces and entrenched themselves in their respective positions. The local's mouthpiece, the *Wisconsin CIO News: Local 248 Edition,* ran articles and cartoons that satirized the company's position and outlined the logic of the union's position. Most of the articles and cartoons called attention to instances in which an individual had suffered discrimination or had been refused a contractual right. For example, the paper cited cases in which a foreman had refused an employee the right to call his shop steward in order to file a grievance. In another instance, the paper satirized the company's practice of calling in timestudy experts to determine the rate at which a task should be performed. Often the timestudy experts cut the allowable task time. Thus those employees who were paid not only a base rate, but also according to the number of tasks completed, found the company cropping their wages to fit the projection of the timestudy. Again, the issue was one of shop authority, and the union had no voice in the procedure.

Even before the strike had been authorized at the West Allis works, the rhetorical battles had begun. Walter Geist, the company president, began mailing letters to Allis-Chalmers' employees explaining the company's position. Geist's first set of letters offered members of the "Allis-Chalmers family" assurances that none of their rights as workers were being violated and that wage demands would be met as soon as the Wage Stabilization Board reviewed Allis-Chalmers' wage increase application. The company also sent out a letter to all employees refuting the "claims made in these [Local 248] flyers," which were "examples of irresponsibility and untruthfulness which bring discredit upon the Union and its leadership." The company also claimed Local 248 designed these flyers to "mislead employes into supporting a strike" and that the local was "trying to do this by the propaganda method." From the beginning of the strike, the company's rhetoric was inflammatory; as the strike wore on, the intensity of the propaganda increased greatly.[13]

In the *Wisconsin CIO News: Local 248 Edition,* Local 248 printed responses to the Company letters and to the articles published in the local newspapers. Besides appealing to union membership through these rebuttals, Local 248 printed a book of labor poetry entitled *The Pavement Trail.* The volume came out in June of 1946 and is a good barometer of employee attitudes at the time of the strike. The following example is a satirical profile of Harold "Buck" Story, Allis-Chalmers' executive attorney and labor policy engineer.

Ode to Buck Story

Buck's pictures lately
So royal and stately
Have enhanced our newspaper pages.
No use denying
Old Buck keeps trying
To look like the King of the Sages.

Buck's quite a guy
But there's more meets the eye
In sizing up this venerable gent.
He's tried since the beginning
To give the Unions a skinning;
He's after organized labor hell bent.

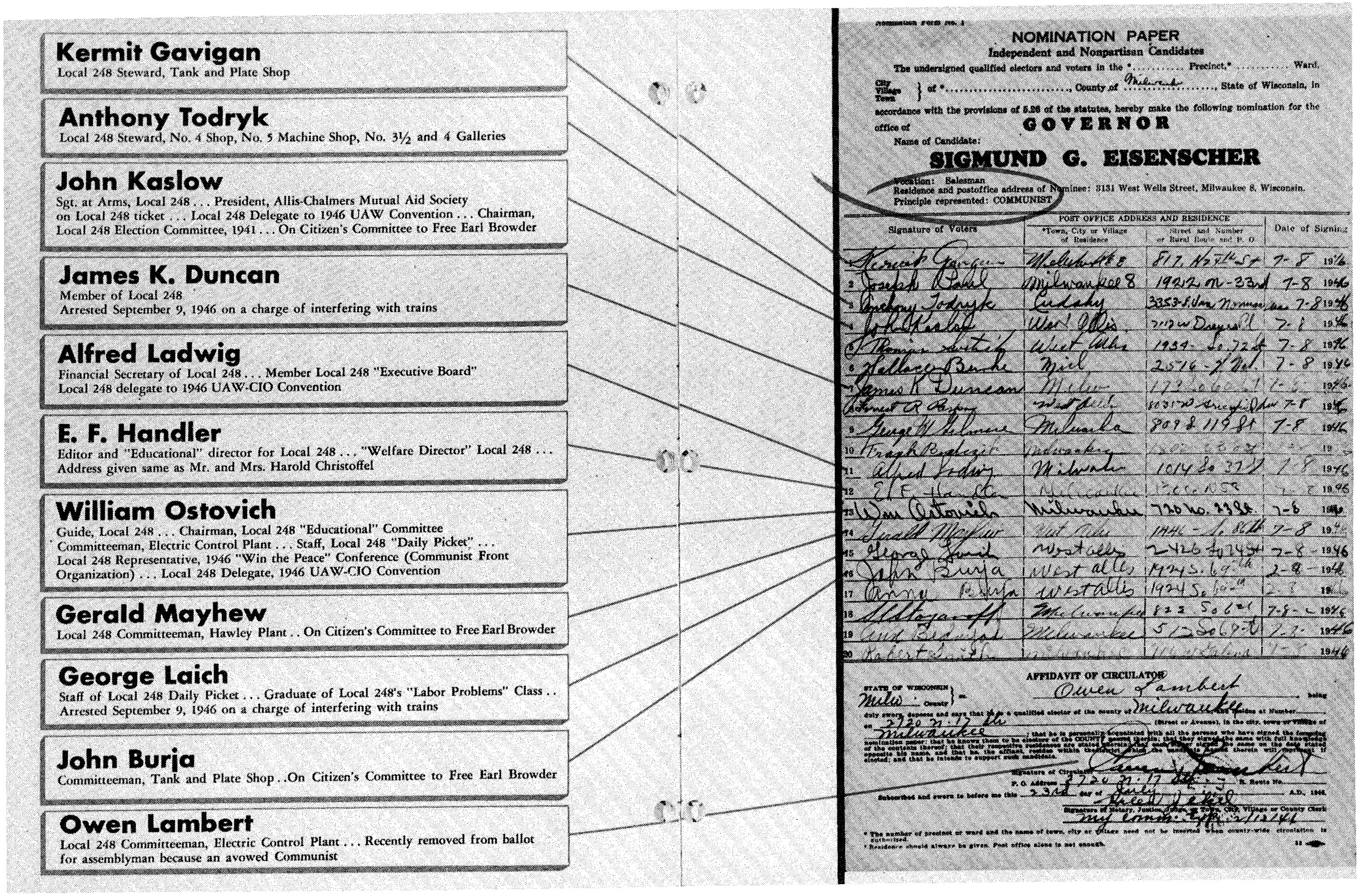
Buck's toothy grin
Is misleading as sin;
He wants the Union forever dissolved.
Don't let him succeed
'Cause brother you'll bleed
All, or nothing at all, he's resolved.

His platinum locks
And loud-colored socks
Could easily put you off guard.
But brother, don't turn
Or your tail-end he'll burn;
He wants Unionism feathered and tarred.

He's a right smart dresser
And at tricks a good guesser
To the public he appears ready and willing.
Old Buck would be good
Were he in Hollywood
As a villain he'd get a number one
billing.[14]

Besides taking jabs at leading Allis-Chalmers' executives, poems and prose in *The Pavement Trail* also satirized the company's anti-union stance, explained their unwillingness to bargain, and served as rousing shows of union solidarity.

After the publication of *The Pavement Trail,* Allis-Chalmers responded with letters to its employees explaining the company's position on the maintenance-of-membership clause and the modification of grievance procedures. In both cases the company demonstrated its desire to maintain control over its employees and the shop floor without having to contend with Local 248. The company maintained that it should have the final say in the case of dismissals and that employees should feel free to come to their foreman with a production problem before seeking a union steward. From a union perspective, the problem with the foreman's maintenance of control over the initial step in the grievance procedure was that it did not protect employees from being coerced back to work or prevent the foreman from simply denying workers' complaints. In September 1946, the letters sent out by Allis-Chalmers changed tone. Instead of continuing to outline the company's stance on contractual differences, the letters informed employees that other plants were already returning to work after having settled and that some of the West Allis works' employees were asking, "Can I go back to work?"[15]



Kermit Gavigan
Local 248 Steward, Tank and Plate Shop

Anthony Todryk
Local 248 Steward, No. 4 Shop, No. 5 Machine Shop, No. 3½ and 4 Galleries

John Kaslow
Sgt. at Arms, Local 248 . . . President, Allis-Chalmers Mutual Aid Society on Local 248 ticket . . . Local 248 Delegate to 1946 UAW Convention . . . Chairman, Local 248 Election Committee, 1941 . . . On Citizen's Committee to Free Earl Browder

James K. Duncan
Member of Local 248
Arrested September 9, 1946 on a charge of interfering with trains

Alfred Ladwig
Financial Secretary of Local 248 . . . Member Local 248 "Executive Board"
Local 248 delegate to 1946 UAW-CIO Convention

E. F. Handler
Editor and "Educational" director for Local 248 . . . "Welfare Director" Local 248 . . .
Address given same as Mr. and Mrs. Harold Christoffel

William Ostovich
Guide, Local 248 . . . Chairman, Local 248 "Educational" Committee
Committeeman, Electric Control Plant . . . Staff, Local 248 "Daily Picket" . . .
Local 248 Representative, 1946 "Win the Peace" Conference (Communist Front Organization) . . . Local 248 Delegate, 1946 UAW-CIO Convention

Gerald Mayhew
Local 248 Committeeman, Hawley Plant . . On Citizen's Committee to Free Earl Browder

George Laich
Staff of Local 248 Daily Picket . . . Graduate of Local 248's "Labor Problems" Class . .
Arrested September 9, 1946 on a charge of interfering with trains

John Burja
Committeeman, Tank and Plate Shop . . On Citizen's Committee to Free Earl Browder

Owen Lambert
Local 248 Committeeman, Electric Control Plant . . . Recently removed from ballot for assemblyman because an avowed Communist

NOMINATION PAPER
Independent and Nonpartisan Candidates

The undersigned qualified electors and voters in the *.......... Precinct,* .... Ward, City Village Town of *.........................., County of ...., State of Wisconsin, in accordance with the provisions of 5.26 of the statutes, hereby make the following nomination for the office of GOVERNOR

Name of Candidate: SIGMUND G. EISENSCHER

Vocation: Salesman
Residence and postoffice address of Nominee: 3131 West Wells Street, Milwaukee 8, Wisconsin.
Principle represented: COMMUNIST

Signature of Voters	POST OFFICE ADDRESS AND RESIDENCE: *Town, City or Village of Residence	Street and Number or Rural Route and P. O.	Date of Signing

AFFIDAVIT OF CIRCULATOR

STATE OF WISCONSIN, County } ss.

* The number of precinct or ward and the name of town, city or village need not be inserted when county-wide circulation is authorized.
† Residence should always be given. Post office alone is not enough.

The complete flyer may be found in either the Don D. Lescohier Papers or the Harold W. Story Papers.

September 1946 marked the beginning of a more urgent phase in the rhetorical battle of the strike. It was in September that the *Milwaukee Sentinel* began running a fifty-nine–day series of articles examining Communist involvement in the Wisconsin State CIO Council and the Milwaukee County CIO Council. The articles were signed by "John Sentinel," which was "supposedly the pseudonym for a Sentinel reporter," but was actually the pseudonym for an Allis-Chalmers researcher. As the largest CIO union in the state, Local 248 was involved in shaping the policies of both CIO councils. For instance, Local 248's president, Robert Buse, was also president of the Milwaukee County CIO Council. Not only did the state and county CIO organizations come under attack, but so did Local 248's leadership. Using an old offensive tactic, Allis-Chalmers and the municipal police worked closely with the press to construct cases that would incriminate the "Communists" within Local 248 and its leadership.[16]

In October, even though picketing workers had told Walter Geist to "save your postage," Allis-Chalmers continued sending letters trying to start a back-to-work movement. One letter claimed that over 2,500 had already returned to work. Despite having been on strike for five months, Local 248's membership rallied around the returning Harold Christoffel, Local 248's honorary president and founder, who had just returned from military duty. The strike would continue for another six months.

In the middle of October, the company mailed a pamphlet to its employees; the pamphlet cover stated, "Principle represented: COMMUNIST" and then asked, "Would you sign *YOUR* name under this?" The pamphlets were a collection of selected gubernatorial nomination papers for Sigmund E. Eisenscher, whose supporters had circulated his nomination papers on the Allis-Chalmers' picket line. Members of Local 248 who had signed the papers had their signatures pinpointed on the nomination papers and, on the facing page, found their full names with a personal sketch outlined in a bold red block. Allis-Chalmers' management accepted this as proof that Local 248's most active members were Communists.[17]

In the next issue of the *Wisconsin CIO News,* members of Local 248 explained their signatures:

> "I signed because I believe anyone who wants to run for office has a right to. . . ."
>
> "Since when is it illegal to sign nomination papers? I signed all kinds of nomination papers this year—for Republicans, Democrats and Socialists, and the company didn't single me out for signing them. . . ."
>
> "I believe in democracy, and that means free elections and the right of people of all political beliefs to run for office. That's why I signed Eisenscher's papers. . . ."[18]

These statements were not given the press circulation that the Communist charges received in area and national papers. The Milwaukee area, as well as the nation, was exposed chiefly to media stories that were based on information furnished by Allis-Chalmers. As the company's media campaign picked up, the local's popular support dropped.

In the first issue of November, the *Wisconsin CIO News: Local 248 Edition* carried a cartoon entitled "Time Stands Still," which equated Allis-Chalmers' management with the witch hunters of Salem. Still, the paper's sardonic humor could not counter Allis-Chalmers' public press charges against Local 248's leadership, waning popular support, and dropping strike contributions. It is at this point that the lack of support from Local 248's international became critical. The UAW's newly elected president, Walter Reuther, in order to gain his office had pledged to purge the UAW ranks of Communists—in spite of his own leftist sympathies. Because of this pledge and, perhaps even more important, because he could not set aside his personal loathing of Local 248's founder and honorary president, Harold Christoffel, or his "machine," Reuther withheld the international's full support.[19]

Even the CIO offered Local 248 only halfhearted support. Philip Murray, the CIO's president, had never been able to work with Communist members of the CIO in the same detached manner that former CIO president John L. Lewis had. Lewis used to "wave aside charges that he was harboring Communists with the comment, 'I do not turn my organizers or CIO members upside down and shake them to see what kind of literature falls out of their pockets.'" Murray, being staunchly conservative and a devout Catholic, was repulsed by CIO Communists and their fellow travelers. In fact, Murray and his friends often sneered at "pinkos" like Reuther. Following the war, there was growing pressure on Murray to purge the CIO.[20]

As the 1946–1947 strike reached its climax in the final months of 1946, Walter Reuther offered the local the assistance of the UAW's former president and current vice-president, R. J. Thomas, although Reuther himself did not become directly involved. Philip Murray also failed to take an active role in the local's fight and, for the most part, remained aloof from the strike. This lack of wholehearted, visible support from both the UAW and the CIO was another factor contributing to the eventual loss of the strike. It seemed as though the national union leaders viewed Local 248's desperate situation as an opportunity to oust the union's leaders.

At the beginning of November, R. J. Thomas came to West Allis in order to give the public a show of UAW support. November was marked by the most public displays of the local's power and shows of force by the municipal police: large parades were organized, more strikers were placed on picket duty, and the police force became more visible. The UAW and the CIO called on other unions to offer their support to the striking Allis-Chalmers' workers. Members of area locals would often join strikers on the picket line or parade. The UAW's largest local, Local 600 from the Ford plant in Michigan, sent its key union members with their "sound truck" so that Local 248 would get an opportunity to tell its story to the Milwaukee public.

R. J. Thomas also served as a negotiator during the November talks with Allis-Chalmers. Members of the UAW's executive board accused the company of using the Communist charges to sidestep the contractual issues under contention. Even after talks were moved to Chicago for the convenience of the federal negotiators, the company remained "defiant" and in an off-the-record comment said that "they had the strike won; their propaganda barrage had borne fruit and that public opinion was in their favor." The talks ended at the beginning of December; Thomas said that bargaining with the company was like "bargaining with a stone wall." Additional reports from UAW representatives stated that employee wages at Allis-Chalmers were below area industrial wages and, again, stated that the company was avoiding the real issues under contention in favor of the Communist "hype."[21]

The strike continued into December with little change. The number of demonstrations picked up and so did police involvement. There were incidents of violence on the picket lines. In December, Allis-Chalmers dismissed Robert Buse, Local 248's president, and Joseph Dombek, Local 248's vice-president, for making statements against the company. Finally, at the end of the month, after a

Taken during the height of picket-line violence in the winter of 1946, the photograph was part of the evidence submitted by Allis-Chalmers during the 1947 congressional hearings as purportedly showing Communist-inspired violence.

series of political maneuvers involving charges of rigged elections, state CIO positions were lost by officers sympathetic to Local 248. Letters from other Allis-Chalmers' locals continued to encourage Local 248 to hold out even though all other striking locals had been forced to sign contracts in order to preserve their unions. Despite the encouragement from other locals, Local 248's strike power was declining.

By January 1947, Allis-Chalmers refused to bargain with Local 248's leadership and refused Thomas' offer to submit the dispute to arbitration. The company waited until an independent union formed and called the Wisconsin Employment Relations Board (WERB) for a representative vote within Local 248. Following this direct challenge to Local 248's bargaining and plant authority, telegrams were sent and announcements made in support of the local by the UAW's and the CIO's two most obviously silent members: Philip Murray and Walter Reuther offered the local encouragement and also told strikers that only a vote for Local 248 would win the strike. After the local won the WERB election by only a narrow margin, some ballots were challenged by the WERB, of which Harold Story, the Company's attorney, was a member, according to the local's newspaper. Local 248 was again confronted with the possibility of having to face another election.[22]

While Local 248 held its officer elections during the last part of February and saw all of its incumbent officers reelected, Allis-Chalmers, working in conjunction with the editor of the *Milwaukee Sentinel,* invited the Committee on Un-American Activities and the Committee on Education and Labor to investigate what the company alleged to be the Communist leadership of Local 248. The hearings before the Committee on Un-American Activities began in Washington, D.C. at the end of February and concentrated on interviewing opponents of Local 248 and its leadership. At the beginning of March, hearings began in Milwaukee before the Committee on Education and Labor, which focused on Local 248's most active members. While investigating Communism in American labor unions, the hearings concluded, based on guilt by association, that certain members of Local 248 were Communists. Both the *Milwaukee Sentinel* (a member of the Hearst syndicate) and the *Milwaukee Journal* gave the hearings primary coverage. The final cooperative push by Allis-Chalmers' management, the *Milwaukee Sentinel,* and the Congressional committees played a major part in breaking the strike and led to the expulsion of Local 248's leadership.[23]

By the beginning of March, there were an estimated 5,000 workers back in the West Allis plant. Local 248 continued the strike, despite the continued attacks from Allis-Chalmers' management, the local and national press, and Congressional hearings, and despite only halfhearted support from the UAW and the CIO. Moreover, after the state and county CIO conventions elected less sympathetic officers, the strikers faced diminished support from their own area locals. At the end of March, Harold Christoffel was discharged by Allis-Chalmers, and Local 248 sent its officers to meet with UAW-CIO heads in order to discuss proposals to break the stalemate. On 24 March 1947, employees returned to work without a contract.

On the day that the strike ended, Walter Geist sent a letter to all employees announcing "THE STRIKE IS OVER!" and outlining, once again, the company position:

> . . . we will continue to fight with all our strength against those who try to undermine the relations between you and the Company.[24]

The eleven-month strike had been a contest over the control of employee loyalty and the West Allis plant. Yet, most of the rhetoric surrounding the strike concerned itself with the Communist issue: the company's accusations and the local's refutations.

Although the *Wisconsin CIO News* reported "248 Surprise Move Throws A-C in Panic," the decision to return to work without a settlement was, in fact, a last effort to save Local 248 before the company called another WERB representative election.[25] In a letter to Allis-Chalmers' employees, Walter Geist summed up the strike in this fashion:

> As the Company prospers we will prosper with it. By the Company I mean every man and woman on the payroll because *you are the Company.* You are Allis-Chalmers. Together we are a big family—there are 29,000 of us.
>
> In the lives of nearly every family there comes a time at home when little frictions develop. We recognize these things as a normal part of living together, but we don't let people on the outside of our own family circle magnify these differences. . . .
>
> . . . It is important, however, that all of us keep in mind the motives of those who attempt to magnify our differences in an effort to destroy our friendly relations and to promote an outside selfish interest.[26]

The letter's tone indicates that even after the strike Allis-Chalmers' president still desired to foster a paternalistic company-employee relationship. From Geist's perspective, Local 248 and its leadership were outsiders who had disrupted the development of an Allis-Chalmers' employee family. By mid-April, over ninety of Local 248's most active members, most of whom were longstanding Allis-Chalmers' employees, were dismissed by the company in an effort to remove the perceived threat. In a *Milwaukee Journal* interview, Walter Geist said that it was a "tonic" for him to see the plant running again and did not feel there would be any more difficulties now that the "troublemakers" were gone.[27]

Because some of the dismissed union members were also those who were elected to bargain with Allis-Chalmers, the company's management refused to bargain with the selected committee. Walter Reuther, UAW president, came to Milwaukee to discuss an agreement with Allis-Chalmers without notifying Local 248's leadership, thus undermining any hope of recovery that the local's leadership had harbored. Shortly after the UAW's fall convention in 1947, Reuther placed Local 248 under administratorship.

In November 1947, Pat Greathouse was chosen to serve as Local 248's administrator. In February 1948, Reuther extended his administratorship to ensure that the "recalcitrant local" would be brought into his camp. Before his departure in July, Greathouse had scheduled new officer elections, appointed interim stewards, and had filed charges against thirteen former Local 248 officers for misappropriation of funds. Then, in that same year, after new union officers conducted an inquiry, Harold Christoffel and key members of his administration were expelled from Local 248. Public opinion had changed. And Allis-Chalmers had succeeded in forcing the removal of "the devastating destructiveness of Communist union leadership" in Local 248.

Endnotes

[1] Harold Story, "Address to the National Association of Manufacturers"; cited in Robert W. Ozanne, "The Effects of Communist Leadership on American Labor Unions" Ph.D. dissertation, University of Wisconsin—Madison, 1954, pp. 232–233.

[2] Ozanne, "The Effects of Communist Leadership," p. 189.

[3] Bert Cochran, *Labor and Communism: The Conflict that Shaped American Unions* Princeton: Princeton University Press, 1977, p. 169.

[4] Stephen Meyer, "The State and the Workplace: New Deal Labor Policy, the UAW, and Allis-Chalmers in the 1930s and 1940s," paper prepared for NEH-funded Research Conference, Dekalb, Illinois, 10–12 October, 1984, pp. 15–16.

[5] Harvey Levenstein, *Communism, Anticommunism, and the CIO.* Westport, Connecticut: Greenwood Press, 1981, pp. 162, 174.

[6] See *Wisconsin CIO News: Local 248 Edition,* 4 January 1946, p. 8; 15 February 1946, p. 8; Cochran, *Labor and Communism,* p. 272; Walter F. Peterson, *An Industrial Heritage: Allis-Chalmers Corporation.* Milwaukee: Milwaukee County Historical Society, 1976, p. 343.

[7] Ozanne, "The Effects of Communist Leadership," p. 235.

[8] David M. Oshinsky, *Senator Joseph McCarthy and the American Labor Movement.* Columbia: University of Missouri Press, 1976, p. 30.

[9] See David M. Oshinsky, *A Conspiracy So Immense: The World of Joe McCarthy.* New York: Free Press, 1983. Chapter Six for a discussion of the Red Bogey in America.

[10] Lawrence S. Wittner, *Cold War America: From Hiroshima to Watergate.* New York: Praeger Publishers, 1974, p. 88.

[11] Peterson, *An Industrial Heritage,* p. 345.

[12] Walter Geist, *Allis-Chalmers: A Brief History of 103 Years of Production.* Princeton: Princeton University Press for Newcomen Publications, 1950, p. 23.

[13] See Walter Geist to All Men and Women of Allis-Chalmers, 17 April 1946; W. C. Van Cleaf to Allis-Chalmers Workers' Union, 25 April 1946, Box 1, Folder 5, Don D. Lescohier Papers, Wisconsin State Historical Society, Madison, Wisconsin.

[14] From *The Pavement Trail: A Collection of Poetry and Prose from the Allis-Chalmers Picket Lines, 1946,* Adolph Germer Papers, WSHS, Madison, Wisconsin.

[15] See W. C. Van Cleaf to All Employes at the West Allis Works, 19 June 1946; 25 July 1946; 20 September 1946, Box 1, Folder 5,

DDL Papers, WSHS, Madison, Wisconsin.

[16] See Levenstein, *Communism, Anticommunism, and the CIO,* pp. 236, 248 and Cochran, *Labor and Communism,* p. 273.

[17] The majority of secondary sources that discuss either the 1941 or 1946–1947 strikes at Allis-Chalmers work under the assumption that officers of Local 248 were Communists. These same sources cite Robert Ozanne's dissertation as their major source, but also cite newspaper articles, Congressional hearings, or the gubernatorial nomination papers circulated on the Allis-Chalmers' picket lines during the 1946–1947 strike. In his 1954 dissertation, Ozanne uses all of the sources mentioned as well as anonymous interviews in an attempt to prove that Harold Christoffel and members of his administration were Communists.

Ozanne failed to take into consideration that the area and national press and Congressional committees worked in close association with Allis-Chalmers, which had something to gain by ousting the longstanding leadership of Local 248. Ozanne's reliance on anonymous interviews which, given the time frame and the fact that they were probably granted by rivals of the Christoffel administration, may be discredited as well. The one piece of evidence that may have proved convincing to Ozanne was the gubernatorial nomination papers that members of Local 248 signed. He did not consider, however, that nomination papers can be signed by any voter of any party affiliation and that they were circulated on the picket lines during the 1946–1947 strike. And as Sigmund G. Eisenscher, the Communist gubernatorial candidate, points out in a letter to R. J. Thomas: "The only persons involved who had in any way pledged themselves to support my candidacy as such were those who *circulated* the petitions—not the signers."*

* (Sigmund G. Eisenscher to R. J. Thomas, 14 February 1947, Box 1, Folder "Correspondence, 1941–1951," Fred Basset Blair Papers, WSHS, Madison, Wisconsin.)

[18] *Wisconsin CIO News,* 18 October 1946, p. 1.

[19] Levenstein, *Communism, Anticommunism, and the CIO,* pp. 83–84, 199–200.

[20] Cochran, *Labor and Communism,* pp. 97, 265–267.

[21] See *WI CIO: 248,* 8 November 1946, p. 8; *WI CIO News,* 15 November 1946, p. 3; 22 November 1946, pp. 1, 3; 29 November 1946, p. 3.

[22] See *WI CIO News,* 10 January 1947, p. 3; 17 January 1947, pp. 1, 4, 4A; 31 January 1947, p. 3; 14 February 1947, p. 3; 21 February 1947, p. 1.

[23] See *WI CIO News,* 14 February 1947, p. 1; *WI CIO: 248,* 28 February 1947, p. 8; Levenstein, *Communsim, Anticommunism, and the CIO,* pp. 242, 246.

[24] Walter Geist to All Employes at West Allis Works, 24 March 1947, Box 1, Folder 5, DDL Papers, WSHS, Madison, Wisconsin.

[25] See *WI CIO News,* 28 March 1947, p. 2 and Cochran, *Labor and Communism,* p. 275.

[26] Walter Geist to All Employes at West Allis Works, 4 April 1947, Box 1, Folder 5, DDL Papers, WSHS, Madison, Wisconsin.

[27] See *WI CIO: 248,* 11 April 1947, p. 8; *WI CIO News,* 18 April 1947, p. 1; and *Milwaukee Journal,* Business Section, 6 April 1947, p. 11.

Primary Sources

In order to provide a contrast and complement to secondary sources that examine the 1946–1947 strike at Allis-Chalmers, this paper's primary sources are *The Wisconsin CIO News* 1945–1948 and *The Wisconsin CIO News: Local 248 Edition* 1945–1947, Local 248's press. The *Milwaukee Journal* 1946–1947 and the *Milwaukee Sentinel* 1946–1947 were also consulted, but are used thoroughly in Ozanne's dissertation. Manuscript collections of Fred Basset Blair, Adolph Germer, Don D. Lescohier, and Harold W. Story were also consulted. These collections are housed by the Wisconsin State Historical Society in Madison. The Lescohier Papers contain the official letters of Allis-Chalmers that are addressed to its employees and the Local during the strike years; the Story Papers contain the official testimony of Allis-Chalmers' officials before the Congressional committees in 1947. Government documents consulted were the Congressional hearings before the Committee on Un-American Activities, *Hearings Regarding Communism in Labor Unions in the United States,* 80th Cong., 1st sess., 1947 and Congressional hearings before the Committee on Education and Labor, *Amendments to the National Labor Relations Act, Hearings on Bills to Amend and Repeal the National Labor Relations Act, and for Other Purposes,* 80th Cong., 1st sess., 1947.

Secondary Sources

The most thorough accounts of the 1946–1947 strike at Allis-Chalmers are covered in three unpublished sources: Robert W. Ozanne's 1954 Ph.D. dissertation, "The Effect of Communist Leadership on American Labor Unions," for the University of Wisconsin-Madison; Richard L. Pifer's 1983 Ph.D. dissertation, "Milwaukee Labor During World War II: A Social History of the Homefront," for UW-Madison; and Stephen Meyer's 1984 paper, "The State and the Work Place: New Deal Labor Policy, the UAW, and Allis-Chalmers in the 1930s and 1940s," prepared for an NEH-Funded Research Conference. Ozanne's dissertation is the Local 248 primer, providing valuable background information on the history of Local 248 and its relations with Allis-Chalmers, but the work fails to maintain a scholarly perspective in its commentary about the 1941 strike and subsequent events. Pifer's dissertation provides the most thorough coverage of wartime relations between Local 248 and Allis-Chalmers' management, placing the conflicts in the context of an industrial struggle, not a struggle against Communism. Likewise, Meyer's paper highlights the Allis-Chalmers/Local 248 conflict as a struggle over managerial control. Meyer proves the best secondary source for information and commentary on the 1946–1947 strike.

Published secondary sources that provide peripheral coverage of the strike or more general histories of labor in Wisconsin include Thomas W. Gavett's *Development of the Labor Movement in Milwaukee,* Howell John Harris' *The Right to Manage: Industrial Relations Policies of American Business in the 1940s'* Robert W. Ozanne's *The Labor Movement in Wisconsin: A History,* and Walter Peterson's *An Industrial Heritage: Allis-Chalmers Corporation,* the official history of Allis-Chalmers.

Both Bert Cochran's *Labor and Communism: The Conflict that Shaped American Unions* and Harvey Levenstein's *Communism, Anticommunism, and the CIO* are excellent histories of the growth of American labor unions and leftists' involvement. Both books also provide insights into the roles of the UAW and the CIO in determining the outcome of the 1946–1947 Allis-Chalmers strike. The books *Senator Joseph McCarthy and the American Labor Movement, A Conspiracy So Immense: The World of Joe McCarthy,* both by David M. Oshinsky, and *Cold War America: From Hiroshima to Watergate* by Lawrence S. Wittner, examine the national climate at the time of the strike. Oshinsky and Wittner provide insights into the roots and causes of America's second postwar Red Scare and America's reactions to the perceived Communist threat.

Fishes of the Upper Trout River, Vilas County, Wisconsin

John Lyons

Abstract. *The Trout River, a small warm-water river in north-central Wisconsin, contains a rich assemblage of fishes over the upper 7.5 kilometers of its length. The river has at least 36 species, 62% of the total number reported for Vilas County. One short stretch contains at least 29 species and another contains at least 25, which is greater than the number encountered at over 99% of 1151 stretches on similarly sized streams and rivers in southern and western Wisconsin. Four of the species found in the Trout River, the pugnose shiner* (Notropis anogenus), *the greater redhorse* (Moxostoma valenciennsi), *the northern longear sunfish* (Lepomis megalotis pelastes), *and the least darter* (Etheostoma microperca), *are rare in all parts of Wisconsin, while two others, the banded killifish* (Fundulus diaphanus) *and the fantail darter* (Etheostoma flabellare), *are rare in north-central Wisconsin. The Trout River should be managed primarily to protect its unusual fish fauna and wilderness characteristics and secondarily to increase its recreational use.*

North-central Wisconsin has a large number and diversity of lakes, streams, and rivers. The fish populations of the lakes have been heavily studied since the turn of the century, but the fish populations of the streams and rivers have received much less attention. Studies of streams have been restricted for the most part to waters cold enough to support trout. Warm-water streams and rivers in the region have been essentially ignored by biologists; species lists for most of these streams and rivers are incomplete, and in many cases even the presence or absence of major gamefish species is uncertain (Black et al. 1963).

Fishing pressure is heavy in north-central Wisconsin, and many lakes in the region are crowded with anglers, boaters, and swimmers during certain times of the year. One possible way to relieve this congestion, as well as to increase recreational opportunities, is to develop and promote fishing and boating in warm-water streams and rivers (Wisconsin Department of Natural Resources 1979). At present, warm-water streams and rivers in north-central Wisconsin are little-used relative to lakes. Development and promotion of fishing opportunities in these streams and rivers requires an evaluation of their potential fishery resources. The first part of such an evaluation is a description of fish species composition and relative abundance.

Data on the fishes of warm-water streams and rivers in north-central Wisconsin is also necessary in order to preserve rare and endangered species. The distribution and abundance in north-central Wisconsin of the fishes on Wisconsin's Endangered, Threatened, and Watch Lists is poorly known. Elsewhere in Wisconsin most of the fishes on these lists are limited to warm-water streams and rivers (Becker 1983).

In this paper, I present the results of the first detailed survey of the fishes of the

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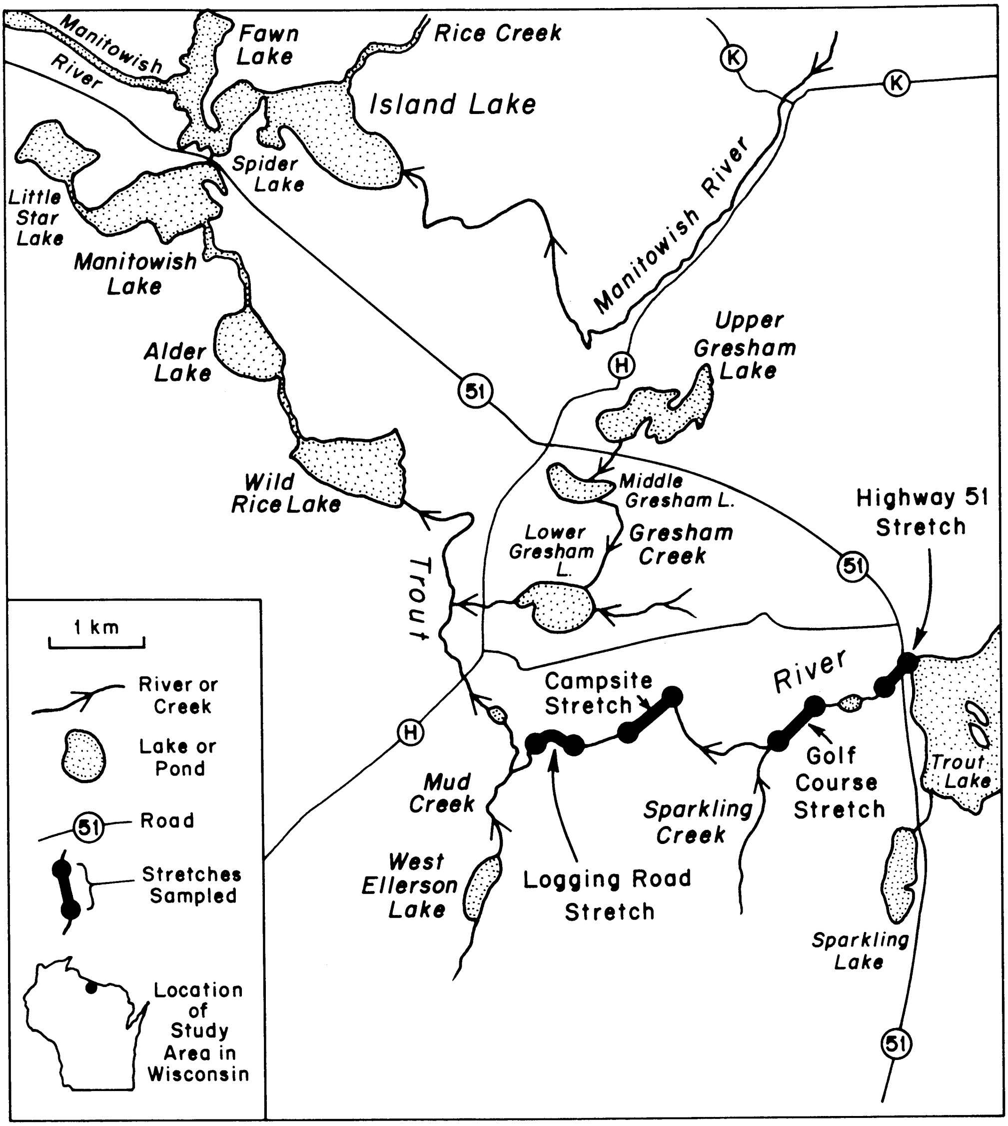

Fig. 1. Map of the Trout River and vicinity, showing sampling locations. For clarity, only rivers and lakes directly connected with the Trout River are shown.

Trout River, a small warm-water river in north-central Wisconsin. Almost nothing is known about the fishes of this river, although the high potential value of the river for angling was recognized over twenty years ago (Black et al. 1963).

Study Area

The Trout River is located in central and western Vilas County (Fig. 1). The river arises from Trout Lake and flows 22 kilometers west and north to its confluence with Manitowish Lake and the Manitowish River. Water from the Trout River ultimately empties into the Mississippi River. Over the upper 11 kilometers of its length the Trout River receives water from three permanent tributaries, whereas over the lower 9 kilometers the river flows through three lakes. Four permanent tributaries drain into Trout Lake and could be considered the headwaters of the Trout River.

I sampled only in the upper 7.5 kilometers of the Trout River, from the outlet at Trout Lake to a logging road bridge located about 2 kilometers upstream of the County Highway H bridge (Fig. 1). I sampled within four stretches: 1) a 0.5 kilometer stretch between Trout Lake and the State Highway 51 bridge (Highway 51 stretch), 2) a 1 kilometer stretch just above the river crossing at the Trout Lake Golf Course (golf course stretch), 3) a 1 kilometer stretch adjacent to the wilderness campsites along the river (campsite stretch), and a 0.5 kilometer stretch just above the logging road bridge (logging road stretch). Within each stretch, I sampled a total of approximately 200 meters of the river.

The Highway 51 stretch consists of short deep pools alternating with short deep riffles and runs. Maximum depth of pools is 1.8 meters, while the average width of the river is about 8 meters. Substrate is gravel and cobbles with some sand. Large woody debris are common in and along the river, but macrophytes are rare. Conifer forests line both banks; these banks are low and marshy. Current is swift (up to 1 m/sec) and strong.

The golf course stretch contains varied habitat. Some parts of the stretch are slow-moving (<0.1 m/sec), 15 to 25 meters wide, and up to 2 meters deep. At the head of the stretch the river has formed a pond-like area of several hectares. Bottom substrates are sand and silt, both submerged and emergent macrophytes are common, and the banks are low, marshy, and lined with shrubs. Other parts of the golf course stretch are similar to the Highway 51 stretch with alternating pools, riffles, and runs, and areas of fast current. These parts of the golf course stretch average about 12 meters in width and have a maximum depth of 1.2 meters. Substrate is gravel and cobbles, macrophytes are scarce, and the banks are lined with a mixed hardwood-conifer forest.

The campsite stretch has few riffles and consists mainly of long pools and runs with moderate current (0.1 to 0.6 m/sec). Width averages 12 meters and maximum depth is 1.3 meters. Substrate is sand and gravel, with a few cobbles and boulders. Large woody debris and submerged and emergent macrophytes are common. A mixed conifer-hardwood forest lines the banks.

The logging road stretch also has few riffles and a moderate current. Width averages 11 meters and maximum depth is 2.2 meters. Substrate is sand and gravel, with silt in areas of slower current. Submerged macrophytes are common and emergent macrophytes line the banks. A mixed conifer-hardwood forest covers the upland away from the river.

Water quality in the Trout River is excellent. The water in the river is very clear and rarely becomes turbid, even after heavy rains. The only permanent human habitation along the upper part of the river is the golf course, and here a buffer zone of undisturbed vegetation appears to minimize runoff and erosion into the river. The forests in the vicinity of the river are regularly logged, and erosion from clear-cut areas could have a negative impact on water quality. However, from the appearance of the forests, the area within a few hundred meters of the river has not been logged in many years, so logging impacts on the river are probably low. The Trout River has slightly alkaline water, with a pH of 7.5, a methyl-orange alkalinity of 41 mg/1, and a conductivity of 87 umhos/cm (Black et al. 1963).

Methods and Materials

I sampled the Trout River for fish from 1980 through 1984, although I did not sample every stretch in every year. All my sampling occurred between mid-May and early October.

I used a variety of gears to sample each stretch. In riffles and other areas of swift current, my primary sampling gears were seines (3.2 or 6.4 mm stretch mesh) and a direct-current backpack electroshocker. In slower-moving water, I also used fyke nets (0.8 m diameter hoops, 10 cm throats, 6.4 mm stretch mesh, 4.6 m leads), dip nets, minnow traps, angling, and visual observations.

Effort and sampling techniques varied from date to date and from stretch to stretch. I expended the most sampling effort at the Highway 51 and campsite stretches, and the least at the golf course stretch. My goal was not to collect detailed quantitative data during each day of sampling, but rather to capture at least one individual of each species present within each stretch and to get a general idea of their relative abundance. I had three abundance categories: common—almost always captured or observed, usually in large numbers (>50 individuals); present—regularly captured or observed, but usually in low numbers (<10 individuals); and uncommon—captured only once or twice, and always in low numbers.

I identified to species and counted all fish that I captured or observed. I preserved one or more individuals of most species that I captured and deposited these specimens in the University of Wisconsin Zoological Museum (UWZM).

I developed species lists and relative abundances for each stretch based on my collections, supplemented with collections made by University of Wisconsin-Madison Field Zoology students during the 1960s and 1970s [UWZM specimens and the Wisconsin Department of Natural Resources (WDNR) Fish Distribution Survey Database (Fago 1984)]. I also developed species lists for areas upstream (Trout Lake and tributaries) and downstream (Manitowish Lake) of the Trout River, using my own collections, collections by other University of Wisconsin-Madison and WDNR personnel, UWZM specimens, the WDNR Fish Distribution Survey Database, Greene (1935), Becker (1983), and Lyons (1984). I also surveyed or requested information on holdings of Trout River fishes in the collections of the Bell Museum of Natural History, Minneapolis, Minnesota, the Milwaukee Public Museum, the University of Michigan Museum of Zoology, Ann Arbor, the University of Wisconsin-Stevens Point Museum of Natural History, and the United States National Museum, Washington, D.C. However, none of these museums had specimens from the Trout River.

Results

I captured 36 species of fish, in 11 families, from the Trout River (Table 1). The dominant families, in terms of number of species, were Cyprinidae (14 species), Centrarchidae (6 species), and Percidae (6 species). The dominant species, in terms of distribution and relative abundance, were the common shiner and the hornyhead chub (Table 2). The most widespread and abundant panfish were the rock bass and the yellow perch. I captured many large rock bass and bluegills, but relatively few large gamefish.

The 36 species that occur in the Trout River represent 62% of the total number of species known from Vilas County (Greene 1935; Becker 1983; WDNR Fish Distribution Survey Database, personal observations). If species that are restricted to lakes or cold water (<22 C) are not counted, the percentage jumps to 73. Sixteen species reported from either upstream or downstream from the Trout River are absent from the Trout River itself (Table 1); most of these species are restricted to lakes or cold water.

The campsite stretch had 29 confirmed species, while the logging road stretch had 25. Most stretches on similarly sized streams and rivers in Wisconsin do not have as many species. The WDNR Fish Distribution Survey sampled 1151 stretches between 5 and 50 m in average width throughout the southern and western halves of Wisconsin, and only one stretch (Mukwanago River, below Phantom Lake, Waukesha County) had more than 29 species (WDNR Fish Distribution Survey Database). Less than one percent of the 1151 stretches had 25 or more species.

The Trout River contains four species, the pugnose shiner, the greater redhorse, the northern longear sunfish, and the least darter, that are rare in Wisconsin (Becker 1983, personal communication; WDNR Fish Distribution Survey Database). The pugnose shiner is on the watch list in Wisconsin (WDNR Bureau of Endangered Resources unpublished data), which means that, while not in immediate danger of extirpation, this species is rare in the state and needs to be regularly monitored to determine whether its population remains stable (Les 1979). The pugnose shiner is found only in the north-central United States and southern Ontario and is nowhere common (Gilbert 1980). This species typically occurs in clear, weedy streams and lakes. These types of habitats are common in north-central Wisconsin, but, excluding one individual that was caught in Manitowish Lake, the nearest other records of this species are hundreds of kilometers to the south and west of the

Table 1. Fish species reported as present from selected areas of the Trout River drainage basin. See Text for sources of data. A "?" indicates that the species is reported or suspected to be present, but is not confirmed.

Common Name	*Scientific Name*	*Manitowish Lake*	*Trout River*	*Trout Lake*	*Trout Lake Tributaries*
SALMONIDAE					
Cisco	*Coregonus artedii*	X		X	
Lake Whitefish	*C. clupeaformis*			X	
Brook Trout	*Salvelinus fontinalis*				X
Lake Trout	*S. namaycush*			X	
ESOCIDAE					
Grass Pickeral	*Esox americanus*	X[1]			
Northern Pike	*E. lucius*	X	X	X	X
Muskellunge	*E. masquinongy*	X	?	X	
UMBRIDAE					
Central Mudminnow	*Umbra limi*		X		X
CYPRINIDAE					
Brassy Minnow	*Hybognathus hankinsoni*		X		X
Hornyhead Chub	*Nocomis biguttatus*		X	X[1]	X
Golden Shiner	*Notemigonus crysoleucas*	X	X	X	X
Pugnose Shiner	*Notropus anogenus*	X[1]	X		
Common Shiner	*N. cornutus*	X	X	X	X
Blackchin Shiner	*N. heterodon*	X	X	X	X
Blacknose Shiner	*N. heterolepis*	X	X	X	X
Spottail Shiner	*N. hudsonius*	X			
Rosyface Shiner	*N. rubellus*	X	X	X[2]	X
Mimic Shiner	*N. volucellus*	X	X	X	X
Northern Redbelly Dace	*Phoxinus eos*				X
Finescale Dace	*P. neogaeus*				X
Bluntnose Minnow	*Pimephales notatus*	X	X	X	X
Fathead Minnow	*P. promelas*		X		X

Table 1. (Continued)

Common Name	*Scientific Name*	*Manitowish Lake*	*Trout River*	*Trout Lake*	*Trout Lake Tributaries*
CYPRINIDAE (Continued)					
Blacknose Dace	*Rhinichthys atratulus*				X
Creek Chub	*Semotilus atromaculatus*		X		X
Pearl Dace	*S. margarita*		X		X
CATOSTOMIDAE					
White Sucker	*Catostomus commersoni*	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*	X	?	?	
Golden Redhorse	*M. erythrurum*		?	?	
Shorthead Redhorse	*M. macrolepidotum*	X	X	X	
Greater Redhorse	*M. valenciennesi*		X	X	
ICTALURIDAE					
Black Bullhead	*Ictalurus melas*	X	X	X	X
Yellow Bullhead	*I. natalis*	X	X		
PERCOPSIDAE					
Troutperch	*Percopsis omiscomaycus*			X	
GADIDAE					
Burbot	*Lota lota*	?	X	X	?
CYPRINIDONTIDAE					
Banded Killifish	*Fundulus diaphanus*		X		X
GASTEROSTEIDAE					
Brook Stickleback	*Culaea inconstans*		X	X	X
Ninespine Stickleback	*Pungitius pungitius*			X	
CENTRARCHIDAE					
Rock Bass	*Ambloplites rupestris*	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X
Bluegill	*L. macrochirus*	X	X	X	X
Northern Longear Sunfish	*L. megalotis pelastes*	X[1]	X		
Smallmouth Bass	*Micropetrus dolomieui*	X	X	X	
Largemouth Bass	*M. salmoides*	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	?	X	
PERCIDAE					
Iowa Darter	*Etheostoma exile*	?	X	X	X
Fantail Darter	*E. flabellare*		X	X	
Least Darter	*E. microperca*	?	X		
Johnny Darter	*E. nigrum*	X	X	X	
Yellow Perch	*Perca flavescens*	X	X	X	X
Logperch	*Percina caprodes*	X	X	X	X
Walleye	*Stizostedion vitreum*	X	?	X	
COTTIDAE					
Mottled Sculpin	*Cottus bairdi*		X	X	X
Slimy Sculpin	*C. cognatus*			X	
TOTAL (confirmed species)		29	36	35	30

[1] = only a few captured; self-sustaining population probably not present.

[2] = the WDNR Fish Distribution Survey Database also reports Emerald Shiners *(Notropis atherinoides)* from Trout Lake, but I believe that this report is based on misidentified rosyface shiners.

Trout River (Becker 1983; WDNR Fish Distribution Survey Database).

The greater redhorse is also on the watch list in Wisconsin (Les 1979). This species is found in the north-central and northeastern United States and southern Canada, and like the pugnose shiner, is nowhere particularly common (Jenkins 1980). The greater redhorse occurs mainly in small to medium-sized warm-water rivers. While these types of rivers are common in north-central Wisconsin, the nearest other records of this species, excluding Trout Lake (Greene 1935; personal observations), are hundreds of kilometers to the south and west of the

Table 2. Relative abundance of fish species in four stretches of the Trout River. C = common or abundant; P = present in moderate numbers; U = uncommon or rare; ? = suspected or reported as present, but no specimens were observed or captured.

	Stretch			
Species	*Highway 51*	*Golf Course*	*Campsite*	*Logging Road*
Northern Pike	P	P	P	?
Muskellunge		?		?
Central Mudminnow			P	P
Brassy Minnow			U	U
Hornyhead Chub	C	C	C	C
Golden Shiner		?		U
Pugnose Shiner			P	P
Common Shiner	C	C	C	C
Blackchin Shiner		?	P	P
Blacknose Shiner		?	C	C
Rosyface Shiner	U	P	P	U
Mimic Shiner	C	C	U	
Bluntnose Minnow	C	C	P	P
Fathead Minnow			U	U
Creek Chub	C	?	P	P
Pearl Dace			U	U
White Sucker	P	?	U	U
Silver Redhorse	?	?		
Golden Redhorse	?	?		
Shorthead Redhorse	U	C		
Greater Redhorse	?	C		
Black Bullhead	U		U	
Yellow Bullhead				U
Burbot				U
Banded Killifish			U	U
Brook Stickleback	U		U	
Rock Bass	C	?	C	P
Pumpkinseed		?	P	
Bluegill			C	P
Northern Longear Sunfish			C	P
Smallmouth Bass	P	?	U	?
Largemouth Bass	U	?	U	?
Black Crappie		?		
Iowa Darter	C	?	U	C
Fantail Darter		P		
Least Darter		P	C	C
Johnny Darter	P	P	P	P
Yellow Perch	P	P	C	P
Logperch	C	P	C	P
Walleye	?	?	?	?
Mottled Sculpin	C	P		
TOTAL (confirmed species)	19	14	29	25

Trout River (Becker 1983; WDNR Fish Distribution Survey Database).

The least darter is also on the watch list in Wisconsin (Les 1979). This species is found in the north-central United States and southern Canada and is fairly common in parts of Michigan (Burr 1980). The least darter occurs in small to medium-sized, clear, weedy streams, and again, while this is a common habitat in north-central Wisconsin, the nearest records of this species are hundreds of kilometers to the south and west of the Trout River (Becker 1983; WDNR Fish Distribution Survey Database).

The northern longear sunfish is threatened in Wisconsin, which means that this species may become endangered and ultimately extirpated if existing populations are not protected (Les 1979). This species is common throughout the central and south-central United States, and the northern edge of the main body of its range is in southeastern Wisconsin (Bauer 1980, Becker 1983). However, isolated populations exist (or formerly existed) in northwestern and northeastern Wisconsin, central Minnesota, northern Michigan, and southern Ontario; the Trout River population can be added to this list of isolated populations. The northern longear sunfish typically occurs in clear, medium-sized streams or small rivers, which are common in north-central Wisconsin, but the nearest populations of this species are 200 kilometers to the east and west of the Trout River (Becker 1983; WDNR Fish Distribution Survey Database). One northern longear sunfish and one northern longear X unknown sunfish hybrid were captured from Manitowish Lake during extensive sampling of the lake in the early 1980s (Harland Carlson, WDNR-Woodruff, personal communication).

Two species that reach the edge of their range and are rare in north-central Wisconsin, the banded killifish and the fantail darter, occur in low numbers in the Trout River. Both species are common in southern Wisconsin (Becker 1983). The fantail darter is also found in low numbers in Trout Lake, whereas the banded killifish is found in low numbers in Stevensons and Mann Creeks, two tributaries of Trout Lake (Greene 1935; WDNR Fish Distribution Survey Database; personal observations).

Discussion

The Trout River contains a diverse assemblage of fishes. This diversity probably results, at least in part, from two factors, the essentially pristine condition of the river, and the wide variety of habitat present. Excluding a minimal amount of runoff from the golf course and logging operations in the watershed, the Trout River is not adversely affected by human activities. Fish species richness in streams generally declines with increasing environmental degradation (Karr 1981). Fish species richness in streams is usually high in areas with diverse habitat (Gorman and Karr 1978), particularly when cover and large woody debris are common (Angermeier and Karr 1984). The Trout River contains a wide range of habitat types, and macrophytes, boulders, and large woody debris are common in many areas. The Trout River also has an unusual combination of both high, medium, and low gradient stretches; diversity of gradient is directly related to fish species distribution and richness in streams (Burton and Odum 1945, Hocutt and Stauffer 1975).

The species richness of the Trout River is probably higher than my sampling indicated. WDNR surveys during the early 1960s reported muskellunge and walleye from the river below the County Highway H bridge. These two species probably occur in small numbers in the stretches that I sampled; my sampling gears were not particularly effective for large gamefish. Golden and silver redhorse have been reported (Harland Carlson, WDNR-Woodruff, personal communication) but not confirmed from Trout Lake, and silver redhorse are present in the Manitowish River and Manitowish Lake (WDNR Fish Distribution Survey specimens). I have observed large aggregations of spawning redhorse in the Trout River in the spring, and I would not be surprised if these aggregations contained silver and possibly golden redhorse. A troutperch was captured at the outlet of Trout Lake in 1908 (UWZM specimen), and this species, which is common in Trout Lake, may occasionally enter the river. During the early 1980s, a lake whitefish used the Trout River to travel between Trout Lake and Little Star Lake (Lyons 1984). Black crappie may also enter the river from Trout or Manitowish Lakes.

The Trout River contains several species that, excluding other waters in the Trout River drainage, have not otherwise been reported from within at least 200 kilometers of Vilas County. Yet many drainages in north-central Wisconsin besides the Trout River appear to contain habitat suitable for at least some of these species. This suggests that the Trout River drainage may be an unusual environment, with some combination of characteristics that does not exist elsewhere in the region. Conversely, the absence of records of these species from outside the Trout River drainage may reflect the lack of sampling of warm-water streams and rivers in north-central Wisconsin, rather than a true absence of these species.

Management Recommendations

The Trout River currently has very little fishing pressure. During all my sampling I saw only three groups of anglers and one group of bait minnow collectors. Clearly the river can support greater fishing pressure. Large panfish are common in the river. Although relatively few large gamefish occupy the river, those present add diversity to angling opportunities on the river and give the angler at least a chance of catching a large fish.

One of the reasons for the low fishing pressure on the Trout River is a lack of access. The only easy public access points in the 7.5 km area that I sampled are the Highway 51 and the logging road bridges. The easiest and probably most popular way to fish the river is from a canoe, floating the river between these two bridges. Fishing float trips on the river are particularly enjoyable because the absence of human habitations or people along the shore gives the river a "wilderness" quality that is all too rare in most parts of Wisconsin. Thus, I suggest that efforts to increase angling on the river focus on encouraging more fishing from canoes, rather than increasing the number of access points.

Given the species-rich fish assemblage and the rare species present, I recommend that the Trout River be managed primarily for preservation of the existing fish assemblage, and only secondarily for fishing. It would be a tragedy if some of the rare fish in the river were eliminated because of a poorly conceived fish stocking or habitat modification designed to improve fishing.

Although much of the river's watershed is state forest land, lumbering in the riparian zone or along tributaries is a potential threat to the continued integrity of the Trout River ecosystem. To protect the fish fauna and undegraded character of the river, I recommend that the portion of the river that I sampled be considered for inclusion in the Wisconsin Natural Areas Program. If designated as a Natural Area, the Trout River would be protected from most sources of environmental damage and would be likely to retain its current fish assemblage for many years to come.

Acknowledgments

I thank Phil Cochran, Louis Doelp, Tim Draissic, Mike Jech, Barry Johnson, Vincent Lyons, Greg Marron, John Osborne, and Dan Schneider for help with sampling. I also thank Harland Carlson for providing information on fish sampling in Manitowish and Trout Lakes, and Don Fago for showing me how to access the WDNR Fish Distribution Survey Database. Cheryle Hughes drew the figure. Support for field work came from the Center for Limnology and the University of Wisconsin Zoological Museum. This report was financed in part by the Federal Aid in Fish Restoration Act under Dingell-Johnson Project F-83-R, Study 501.

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Lightning and the Enlightenment: An Essay on Lightning by G. C. Lichtenberg

Ralph C. Buechler

After Benjamin Franklin had installed a lightning rod on his Philadelphia home in 1749 and performed his legendary kite-flying experiment in 1752, European scientists like Priestly in England, Volta in Italy, and Lichtenberg in Germany soon joined him in the exploration of the nature of electricity.

Probably the least known of these, Georg Christoph Lichtenberg was Professor for Experimental Physics at the newly founded Hanoverian University of Göttingen. This discussion will deal with Lichtenberg's work *Über Gewitterfurcht und Blitzableitung (On Lightning Rods and the Fear of Lightning),* written in 1795 after Lichtenberg became the first citizen of Göttingen to attach a lightning rod to his home.

Lichtenberg understands the fear of thunder and lightning and the imagination underlying it and suggests an enlightened response to these natural phenomena based upon a knowledge of nature (science) and a practical solution to nature (here, the lightning rod). "Tell him," Lichtenberg advises in regard to the uninformed person who trembles at each peal of thunder and flash of lightning, "that lightning, whose thunder shakes the ground, may be led through a bit of wire or a little metal covering to wherever one might want it."[1]

Prior to the latter half of the seventeenth century the nature of electricity was as mysterious as its application. Indeed, observations on electricity were limited to lightning storms on the one hand and to curiosity about the peculiar forces of attraction demonstrated by such minerals as amber and lodestone on the other.

But during the eighteenth century, the understanding of electricity was advanced beyond hearsay, ignorance, and mere conjecture. In 1660 Otto von Guericke of Magdeburg constructed the first primitive electro-static generator; in 1729 Stephen Gray discovered the principle of conduction; and in 1745 Ewald G. Kleist and Pieter van Musschenbroeck independently fashioned the Leyden jar, the first electrical condenser to store an electrical charge.

By the middle of the eighteenth century interest in lightning had taken a central position amidst all this generating, conducting, and storing of static electricity. Once mythified as the thunderbolt of Zeus and Jupiter or as the wrath of God, lightning was now observed to have properties that appeared to be similar to those noted during experimentation with static electricity.

Deducing from his own experiments with static electricity and the Leyden jar,[2] Benjamin Franklin hypothesized as early as 1749 the relationship between electricity and lightning. He subsequently tested his hypothesis in the famous kite experiment of 1752.[3] But even prior to his experiment Franklin had suggested that a sharp metal rod pointed skyward and connected to the ground would attract charges of electricity and lead them into the ground, keeping them away from buildings.[4]

It proved to be of inestimable importance to the European scientific com-

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munity that Franklin wrote of his findings in clear and detailed letters to a certain Peter Collinson, London merchant and member of the Royal Society. These letters were published in the Society's *Transactions,* and Franklin himself was made a fellow of the Society in 1756.

Just two years later Johann Carl Wilcke of Wismar translated Franklin's *Experiments and Observations on Electricity* into German.[5] A dozen years later still, in Göttingen, where Wilcke himself had studied from 1753–1755, Lichtenberg was named professor of experimental physics. In the capacity of researcher and teacher, he studied and repeated the experiments of Franklin and the leading European electro-physicists.

Lichtenberg broke no new ground with his experiments and reflections on electricity; he repeated and varied the work of others before him[6] primarily for self-edification and, most importantly, for his classes at the university.

Lichtenberg's essay *On Lightning Rods and the Fear of Lightning* is not an objective, verifiable, and exhaustive treatment or treatise contributing new knowledge. Why, then, did Lichtenberg write it?

Lichtenberg writes of lightning from the standpoint of the scientist, the philosopher, and the individual who is fascinated and awed by thunderstorms. He collected accounts of storms from his friends and colleagues as avidly as others might collect stamps or coins. He writes in a July 1783 letter: "The news of your thunderstorms was for me as entertaining as it was terrible. I always receive such news with gratitude, especially the exact description of the route taken by the lightning near buildings and other large, physical bodies."[7]

Lichtenberg does not deny the subjective and aesthetic experience of nature. His own notes and the memoirs of his students are replete with his personal, often nervous, responses toward the approach of a storm. In his letters he writes enthusiastically of the sublime nature of thunder and lightning; they both repel and attract him. Thus Lichtenberg remarks in the letter of July 1783 that "my body is, as it should be for the body of a physics professor, a never-failing barometer, thermometer, hygrometer, manometer, etc."[8] Still more revealing is a letter to his friend Franz Ferdinand Wolff on 21 July 1783:

> Just now the first rays of sunshine have appeared after a fearfully beautiful thunderstorm with hail, which has just passed and of which the roofs are still dripping. I was not a little concerned about our town. As the storm arose, it turned almost dark and every flash of lightning struck home. . . . The day had been unbearably hot and I was unusually sensitive, on top of which it is the anniversary of my father's death. Nothing in the world could resemble more my state of mind than such weather. Once, as it thundered deeply, I thought it was directly under me, so I can truly say, I've never felt my mortality more than at that moment. Indeed, tears came to my eyes out of amazement. Surely, there is nothing more grand or majestic.[9]

Lichtenberg attempts from the outset of his essay to demonstrate the unreasonableness of the fear of lightning by developing an analogy between stormy weather and disease. Between the unstable conditions of the atmosphere and the human body, the potential of danger and suffering operates as the point of comparison. Lichtenberg even collapses the two into one metaphor, speaking, for example, of "smallpox weather" or of clothing as "dysentery rods." He begins:

> As I write this (at the beginning of August, 1794) one may note in our vicinity as in others, evidence of dysentery. Already six people are said to have perished; that would be twice as many in a few days as lightning has killed in our city in the last half century; and how many people has dysentery probably killed in that half century? But no one

> seems upset by that. I see that one hardly bothers with the simplest "dysentery rods."[10]

Lichtenberg responds to this unreasonable disparity between perceived and actual danger with an understatement: "Isn't that curious?"

But Lichtenberg does more than identify the human reaction to thunderstorms. He offers three different antidotes: the use of imagination, the use of reason, and the implementation of a practical solution—the lightning rod.

As to the first, if brontophobia (the fear of thunder) is largely the result of an over-active imagination, Lichtenberg suggests employing that same faculty in conjuring up images of true danger, such as a battlefield, so that one may become aware of the ridiculous nature of such irrational fears. He prescribes laughter as an antidote. Recounting an actual case in which a man subject to extreme fear of thunder tried this "antidote," Lichtenberg remarks: "I know that this strategey was so effective, that, while the thunder rolled and the rain beat like hail against the window, the patient himself began to smile at his own fears, due to the obvious contrast."[11]

Second, Lichtenberg identifies the roots of brontophobia in childhood from the use of fear as an instrument of discipline. More dominant still is the power of sound, causing us to misplace our fear in thunder, not lightning. Thus Lichtenberg muses: "I'd really like to know, if anyone has ever heard of someone deaf who is fearful of a thunderstorm."[12] Here he proposes the simple truth as a route out of naivety, prejudice, and ignorance:

> Against this fear—planted by improper upbringing and supported by human nature—I know no other advice than that one instruct the patient in the truth, pure and simple. Explain to him what lightning is without understatement or exaggeration. Compare the dangers of lightning to that of diseases, and demonstrate that thunderstorms are the gentlest of diseases that can befall a city. More persons die of heart attacks in every city in one year than of lightning throughout the whole country in ten years.[13]

On a third level Lichtenberg's attempts at enlightenment reach a practical fulfillment—the use of the lightning rod:

> But now, if it were in our power, perhaps not to destroy, but to control this lightning which frightens us so when accompanied by a barrage of thunder, to protect ourselves from it as we do from the rain? We can, and with the same certainty with which we escape from the rain under a good roof or the sun under a thick shade tree.[14]

Comparing lightning to the cold, Lichtenberg notes the similarity between lightning rods and fuel or clothing. In either case, failure to avail oneself of these protective instruments may result in dire consequences. "Extreme cold is much more horrible and dangerous than all the thunderstorms of six summers together, although the latter causes a great deal more commotion. But is one not afraid of the cold? Because we have proven 'cold rods' against it, namely, fuel and clothing."[15]

Although he does refer to some aspects of the correct installation of a lightning rod,[16] Lichtenberg states outright that "our purpose here is not to give a lesson in proper lightning rod installation." Ostensibly a discussion on lightning and lightning rods, Lichtenberg's essay is really a dialogue between writer and reader on ignorance, superstition, truth, and knowledge. The topic is the nature of lightning, but the theme is human nature.

Lichtenberg's essay seeks to fulfill three major didactic functions. On a psychological level it speaks of the irrationality of human phobias toward lightning by speaking of the truths garnered from the connection established between lightning and electricity. On an aesthetic level he seeks to replace this fear of lightning with the experience of the sublime effect of storms—one can hardly enjoy a good storm if one is afraid of it. Lastly, he speaks of the social welfare that accrues through peace of mind and actual property protection from the construction of lightning rods.

In conclusion, an eighteenth-century German essay on electricity and lightning ultimately proves to be of great value to the general reading public of his time. Lichtenberg's essay functions as a literary lightning rod that serves as an instrument to control, channel, and ground superstition and unreason.

Notes

[1] Georg Christoph Lichtenberg, "Über Gewitterfurcht und Blitzableitung," in *Aufsätze gelehrten und gemeinnützigen Inhalts,* Vol. III of his *Schriften und Briefe,* ed. Wolfgang Promies (München: Carl Hauser Verlag, 1972), p. 133. All subsequent citations of Lichtenberg's essay are taken from this source.

[2] Franklin proposed correctly that, in contrast to the two-fluid theory of Dufay and others, electricity must be understood as a single "fluid" that may be positively charged.

[3] Acting upon Franklin's suggestions, the French scientist D'Alibard charged an electric bottle from a flash of lightning, thus demonstrating the identity of electricity and lightning.

[4] Franklin included a detailed account of the construction and function of the lightning rod in his *Poor Richard's Almanac* of 1753.

[5] See Benjamin Franklin, *Des Herrn Benjamin Franklins Briefe von der Elektrizität,* trans. Carl Wilcke, eds. Roman Sexl and Karl von Meyenn (Braunschweig: Edition Vieweg, 1983).

[6] Lichtenberg's discovery of his "Lichtenberg Figures"—snowflake-like structures of dust on the surface of an electrophor caused by static electrical discharge—represents a minor exception.

[7] "To Gottfried Hieronymous Amelung," 3 July 1783, Letter 398, in *Briefe,* Vol. IV of his *Schriften und Briefe,* ed Wolfgang Promies (München: Carl Hauser Verlag, 1972), p. 515. All subsequent citations of Lichtenberg's letters are taken from this source.

[8] "To Gottfried Hieronymous Amelung," 3 July 1783, Letter 398 in *Briefe,* p. 515.

[9] "To Franz Ferdinand Wolff," 21 July 1783, Letter 402 in *Briefe,* p. 519.

[10] Lichtenberg, "Über Gewitterfurcht und Blitzableitung," p. 130.

[11] Lichtenberg, "Über Gewitterfurcht und Blitzableitung," p. 132.

[12] Lichtenberg, "Über Gewitterfurcht und Blitzableitung," p. 133.

[13] Lichtenberg, "Über Gewitterfurcht und Blitzableitung," p. 133.

[14] Lichtenberg, "Über Gewitterfurcht und Blitzableitung," p. 134.

[15] Lichtenberg, "Über Gewetterfurcht und Blitzableitung," p. 135.

[16] Lichtenberg, was among the first to insist that grounding the lightning rod is the most essential component of proper lightning rod installation.

Land Use and Vegetational Change on the Aldo Leopold Memorial Reserve

Konrad Liegel

Abstract. *This study records land use and vegetational changes on the Aldo Leopold Memorial Reserve in Sauk County, Wisconsin. Vegetation maps were prepared for the early European settlement (1840s) and early Leopold (1930s) eras through interpretation of surveyor's notes, traveller's accounts, soils information, aerial photographs, agricultural records, present vegetation, and on-site observations. These maps, compared with each other and with the present vegetation map (1978, rev. 1986), show trends in vegetational change since the time of settlement. Closed communities of shrub-carr and forest have replaced open communities of low prairie, sedge meadow, and oak savanna. The primary factor responsible for this change is the control of fire.*

Land-use records indicate that agricultural use helped to delay this succession of communities. Grazing kept the savannas open although it destroyed the natural groundlayer. Therefore, in 1940 more prairie species remained in the minimally grazed black oak forests than in the heavily grazed white oak savannas. The mowing of marsh hay, meanwhile, kept the wet prairie and sedge meadow open. When grazing and mowing stopped, shrubs and trees quickly invaded. Agricultural use peaked in the 1920s, but declined in the 1930s through the 1960s due to meager natural soil fertility, the introduction of modern mechanized farming, and farmer attrition.

The plant communities of southern Wisconsin have changed dramatically in the years since glaciation. European settlement and subsequent land use, in particular, thoroughly modified the plant communities, primarily through the control of fires that resulted from lightning strikes and Indian activities (Dorney 1981). In the absence of fire, the sunny oak openings of southern Wisconsin grew up into the oak woodlots of today, while shrub-carr and aspen invaded the sedge meadows and low prairies. Lumbering and farming transformed most of the remaining expanses of prairie, savanna, marsh, and forest into today's fields of corn and hay (Curtis 1959).

This study records the changes in land use and vegetation on what is now the Aldo Leopold Memorial Reserve. The Reserve is the "sand country" of Aldo Leopold, where he and his family spent their weekends and vacations in the 1930s and 1940s restoring a worn-out farm north of Baraboo, Wisconsin. Leopold studied the land-use and ecological history of his farm searching for guidance on how to restore it to a healthy state. Leopold's experiences at the farm also helped in shaping his philosophy of man's relationship to his environment—the land ethic—which is expressed in *A Sand County Almanac* (1949):

> Conservation is getting nowhere because it is incompatible with our Abrahamic concept of land. We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. There is no other way for land to survive the impact of mechanized man, nor for us to reap from it the esthetic harvest it is capable, under science, of contributing to culture.

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It seems fitting, therefore, that the ecological story of the Leopold farm and the Reserve surrounding it be told. This land-use and vegetational history illustrates a principle implicit in the writings of Leopold: the pattern and composition of vegetational communities reflect the choices human cultures have made in land use.

Description of the Leopold Memorial Reserve

The Aldo Leopold Memorial Reserve is a private landowner's cooperative tract of approximately 1400 acres dedicated to the memory of Aldo Leopold. Among other properties, it contains Leopold's original farm, which includes "the Shack," now listed in the National Register of Historic Places. A refurbished chicken coop, later memorialized in *A Sand County Almanac,* the Shack was home to the Leopold family during visits to their farm. The Reserve is located in Fairfield Township, Sauk County, Wisconsin (R7E, T12N, Sec. 2, 3, 4, 5; R7E, T13N, Sec. 32, 33, 34, 35) (Fig. 1) where the Wisconsin River and its floodplain cut a swath through the ground moraine with its wetlands left by the last ice sheet.

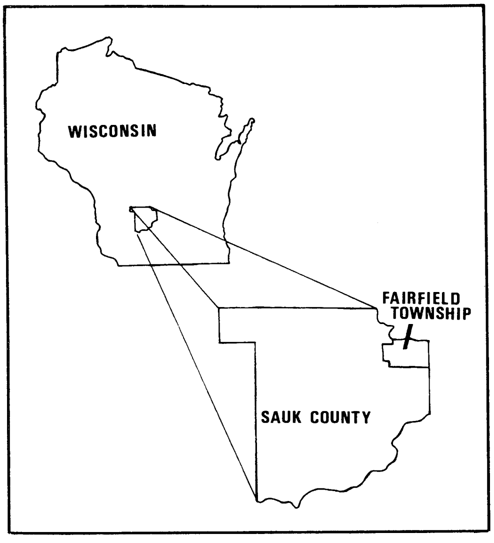


Fig. 1. Location of the Aldo Leopold Memorial Reserve, Sauk County, Wisconsin.

Glaciation, subsequent wind erosion, and the fluvial action of the Wisconsin River have molded the Reserve's surface features (Fig. 2). The Reserve is covered with a mantle of supraglacial sediments and till laid down by a series of glacial advances, the last being the Green Bay Lobe of late Woodfordian age (Black and Rubin 1967–1968), which reached its maximum advance into the area about 13,000 years ago (Socha 1984). As the glacier melted, an extension of Glacial Lake Wisconsin formed to the east of the terminal moraine, covering the Reserve. The north-south-trending ridges in the Reserve area were probably fashioned during this time as deltas in the lake at the ice margin. The proglacial lake existed in the Reserve area until the ice margin cleared the east end of the Baraboo range and uncovered a low area near Portage. The proglacial lake drained through this outlet, establishing the present course of the Wisconsin River. Subsequently, the river eroded the north end of the sand and gravel ridges. Eolian processes reworked both the proglacial fluvial and modern fluvial deposits and formed blowouts and dunes, leaving the topography of today (Socha 1984).

Fire stress, fluctuating water levels, and siltation levels have determined the changing pattern and composition of plant communities on the Reserve (Liegel 1982). Presently, about two-thirds of the area is floodplain forest and marshland, dotted with ponds and laced with river sloughs. The remainder is hilly ground moraine covered by a mixed oak-hickory-pine forest and broken by a few fields still under cultivation (Luthin 1980; Bradley 1987). A deep, sandy substrate underlays the entire Reserve and produces an easily eroded soil of low fertility (Sharp and Bowles 1985).

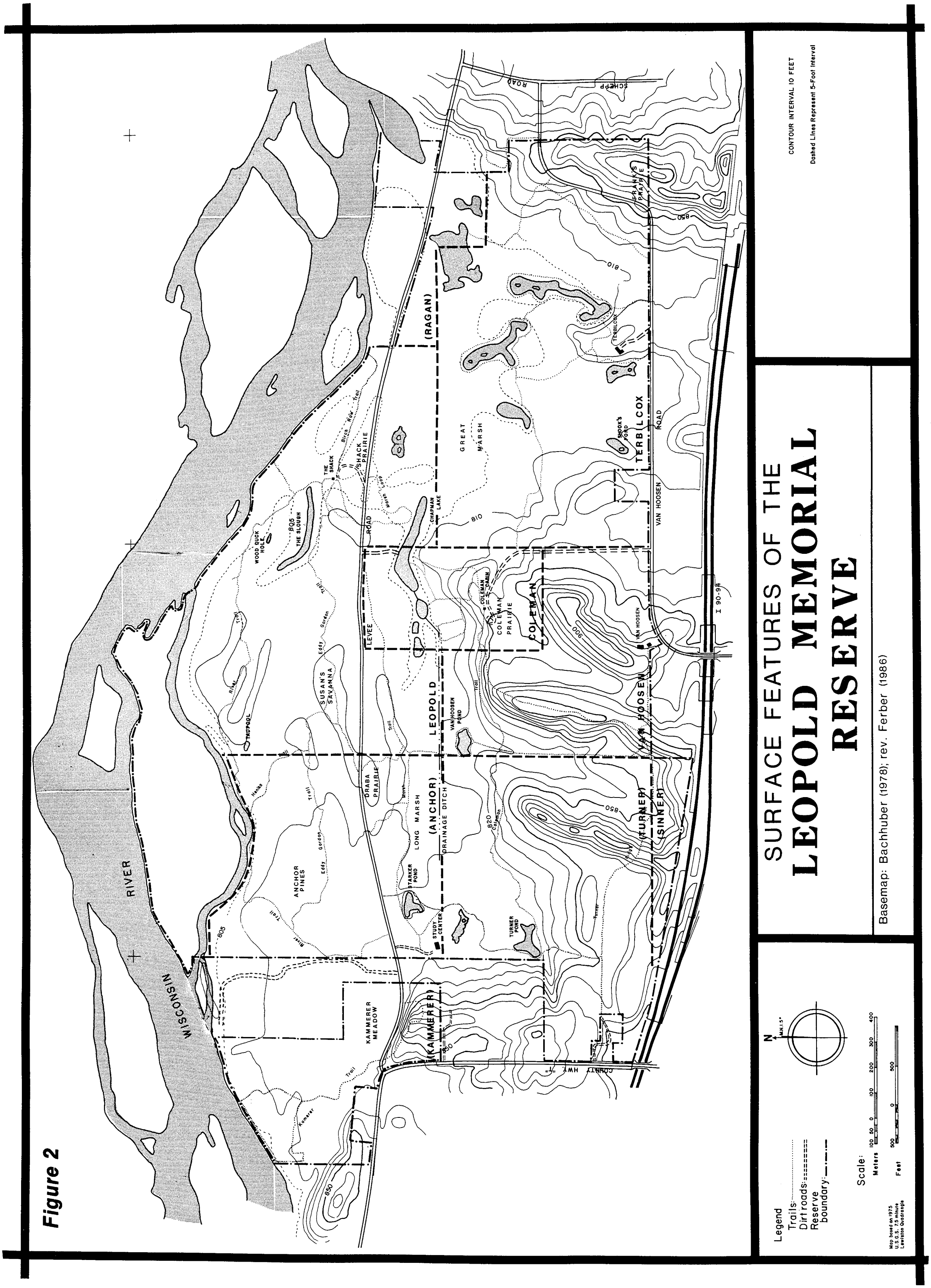

SURFACE FEATURES OF THE
LEOPOLD MEMORIAL
RESERVE
Basemap: Bachhuber (1978); rev. Ferber (1986)
CONTOUR INTERVAL 10 FEET
Dashed Lines Represent 5-Foot Interval
Legend
Trails:
Dirt roads:
Reserve boundary:
Scale:
Meters
Feet
WISCONSIN
RIVER
KAMMERER MEADOW
ANCHOR PINES
SUSAN'S SAVANNA
DRABA PRAIRIE
LONG MARSH
(ANCHOR)
DRAINAGE DITCH
LEOPOLD
STARKER POND
STUDY CENTER
TURNER POND
VANHOOSEN POND
LEVEE
CHAPMAN LAKE
SHACK PRAIRIE
THE SHACK
THE SLOUGH
WOOD DUCK HOLE
TADPOOL
(RAGAN)
GREAT MARSH
COLEMAN PRAIRIE
COLEMAN
(TURNER)
(SINNER)
VAN HOOSEN
TERBILCOX
VAN HOOSEN ROAD
I 90-94
SCHEPP ROAD
COUNTY HWY. T
FRANK'S PRAIRIE
(KAMMERER)

Figure 2

European immigrants settled the area in the 1840s. At that time oak savanna maintained by fires was the dominant ecotype (Liegel 1982). Lumbering, cultivation, drainage of wetlands, overgrazing, mowing, and fire suppression caused rapid changes in the vegetative cover. Farming reached its zenith in the mid-1920s, with farms being abandoned to brush and weeds, wind and weather during the drought and depression of the 1930s. In 1935 Aldo Leopold purchased one of these abandoned farms and started to reverse the process of land deterioration through management and restoration, an activity that continues today under the direction of Frank Terbilcox, Manager, and Charles and Nina Bradley, Co-Directors of Research of the Leopold Memorial Reserve, and through the financial support of the Sand County foundation.

Methods

I based this study of vegetational change on a land-use chronology of the Leopold Memorial Reserve and on a series of vegetation maps of the Reserve during the 1840s (Liegel 1982), 1930s, and 1970s (Luthin 1978, rev. Ferber 1986). Land-use chronologies are an effective tool for generating hypotheses as to the relation between past land-use actions and present ecological effects, for broadly illustrating the significant impact humankind has had on the environment, and for helping to make management decisions (Leopold 1940; Grange 1948; Leopold 1949; Scott 1980). A comparison of vegetation maps for different time periods of the same piece of land, meanwhile, graphically and quantitatively shows the precise changes in percentage land cover by different plant community types over time (Curtis 1959; Vogl 1964).

Land-Use Chronology

This land-use chronology is based on historical documents that covered events within a larger area than the Reserve itself, namely that portion of Wisconsin surrounding the Wisconsin River between Wisconsin Dells and Portage. The historical documents considered include the following: state histories (Smith 1854; Nesbit 1973; Smith 1973; Current 1976); regional histories (Gregory 1932), county histories (Canfield 1861a; Butterfield 1880a and 1880b; Jones 1914; Cole 1918; Lange 1976); the published accounts of early explorers (including Carver [1766] 1838; Nuttall [1810] 1951; Schoolcraft [1820] 1953; Featherstonaugh 1847), pioneers (including Childs 1859; Kinzie 1856), and lumbermen (including Babington 1928); newspaper articles (Baraboo and Portage); and the journals of Reserve inhabitants Melvin Felt (1879–1899), Aldo Leopold (1935–1948), and Charles Bradley (1978–1987).

Written descriptions have their limitations for reconstructing past landscape and land-use patterns. Such historical descriptions are frequently vague, occasionally biased, and almost always very general (Vale 1982). However, for some time periods, especially prior to 1840, they are the only resource a land historian has to reconstruct past vegetation.

Finally, the chronology is based on the 1860–1900 Agricultural Census Schedules for Wisconsin of the U.S. Department of Agriculture (the records for 1910 and 1920 were destroyed in a fire) and the 1923–1972 Annual Enumeration of Farm Statistics by Assessors of the Wisconsin Department of Agriculture, both found in the Archives of the State Historical Society of Wisconsin. The agricultural schedules record, by individual farmer and county, the following statistics: amount of land owned; acreage devoted to various crops, pasture land, marsh hay, woodland, and unplowed land; numbers and kinds of livestock; and use of electricity, centralized heating, tractors, and fertilizers.

Agricultural census records likewise

have their limitations for reconstructing past agricultural-use patterns. Census figures often were conservative estimates from the farmers (Statz 1982, pers. comm.), and occasionally they appeared somewhat incomplete or inconsistent. To minimize these problems, the census figures were closely compared with the other historical documents.

In order to use the records, the land ownership history of the Reserve was determined through a search in the Sauk County Register of Deeds and in individual abstracts for particular properties. Then the agricultural records for each property were tabulated by individual landowner and year. Finally, by comparing the agricultural records with each other, and with the journals of Reserve inhabitants, field observations of the various fence lines, aerial photographs (1937; 1940; 1955; 1968), and various plat maps of Fairfield Township (Canfield 1861b; Tucker 1877; 1906; 1920; 1936; 1947; early 1950s; 1961; 1972; 1976), I was able to determine approximately when individual parcels were cultivated, mowed, or grazed, and for how long.

Vegetation Maps

Vegetation maps were prepared for the early European settlement (early 1840s) and early Leopold (late 1930s) eras of the Leopold Reserve for comparison with each other and with the present vegetation map (1978, rev. 1986) to show trends in vegetational change since the time of settlement. These periods were chosen because of their special importance to understanding the ecological history of the Reserve and because of the availability of survey information and/or aerial photographs for making a map of the vegetation during that period. The plant community types were delineated to follow those described by Curtis (1959).

A detailed description of the methods used in preparing the map of the early European settlement vegetation of the Reserve can be found in Liegel (1982).

The vegetation map of the Leopold Reserve in the late 1930s was prepared from the 1940 Agricultural Stabilization and Conservation Service (ASCS) aerial photograph. Community types and boundaries were derived from the following sources used in conjunction with the 1940 ASCS aerial photograph:

1. The Bordner Land Economic Inventory (1938) for Sauk County, the data originally recorded by field workers who traversed each quarter mile of land, noting both vegetational communities and human land use;
2. The ASCS aerial photograph of 1937;
3. The Shack journals of Aldo Leopold (1935–1948);
4. A herbarium collection of Carl Leopold (1938–1940);
5. Recollections of the Leopold family.

In addition, a stereoscopic wetland mapping procedure, developed by the Wisconsin DNR Wetlands Inventory (Wetlands Mapping Staff 1981), was used to delineate boundaries between different wetland community types that otherwise could not have been delineated on the aerial photographs.

Luthin (1978; 1979; 1980) prepared the present vegetation map through field observations while accompanying a baseline survey of the Reserve. Ferber (1986) revised the vegetation map through comparison with the 1976 infrared and 1978 aerial photographs and through additional field checks. This present vegetation map shows the Reserve boundaries of 1986, whereas the 1840s and 1930s vegetation maps show the Reserve boundaries as of 1980 when the maps were compiled.

The relative area coverage for the different community types was determined by counting dots on a grid placed over each map. The 1980 Reserve boundaries were used in making the calculations so that the relative area coverage for different community types could be quantitatively compared.

Leopold Reserve Chronology

Prehistory (13,000–300 Years Ago)

The Prehistory era was one of great geologic and climatic change, accompanied by a series of changes in vegetation types from the boreal swamp woodlands of the proglacial period to the mosaic of mesophytic forest, oak savanna, and marsh communities found by the earliest European explorers (Maher 1981; Maher 1982; Winkler 1985). The changes in vegetation, in turn, were accompanied by a change from nomadic tribes of Indians to more sedentary tribes (Quimby 1960; Wittry 1979a; Wittry 1979b).

The first documented aboriginal use of the area surrounding and including the Leopold Reserve was by the Effigy Mound culture of the Woodland Indians about 700 to 1200 years ago (Quimby 1960). Although they still lived by hunting and fishing, the Woodland Indians were the first people in the region to use pottery of fired clay, to raise crops, and to erect mounds over their dead or in the shape of effigies. Several Effigy Mound culture mounds were found near or within the Leopold Reserve, including a possible village site southwest of the Terbilcox residence (Stout 1906; Brown 1924) (Fig. 2). Unfortunately, nothing more is now known about the aboriginal land use of the Reserve area during this period.

Exploration Era (1660–1836)

Social upheaval characterized the Exploration Era. The French, the English, and later the Americans fought for control of the region, and Indian tribes displaced one another as European settlers pushed them westward (Smith 1973). Indian tribes exerted an indirect but substantial effect over the composition of plant and animal communities through the use of fire (Day 1953; Martin 1973; Lewis 1980; Dorney 1981). European trappers affected plant community composition to a somewhat lesser, but perhaps still significant, degree through overexploitation of fur-bearing and large game animal species (Cole 1918; Smith 1973).

The Wisconsin River was the principal means of transportation in the study area prior to settlement. Descriptions of the vegetation and animal life along its banks provide the best evidence of ecological conditions during this period.

When the French explorer and first European visitor Father Marquette paddled his canoe up the Fox, across the Portage, and down the Wisconsin River in 1673, he found a wild land with few Indians and much game. He wrote of the Wisconsin River:

> On the bank one sees fertile land, diversified with woods, prairies, and hills. There are oak, walnut, and basswood trees; and another kind, whose branches are armed with long thorns. We saw there neither feathered game nor fish, but many deer, and a large number of elk. (Kellogg 1917)

Soon after Marquette's explorations, French trappers plyed the Fox-Wisconsin route in search of gold, fur, and skins (Smith 1973). The fur trade system, which continued for the next 125 years, altered the relationships between Europeans and Indian tribes by making the Indians dependent upon French-supplied weapons, traps, ammunition, and blankets (Kellogg 1925). The Indians received these supplies on credit, which they paid for by furs.

The cumulative effect of excessive trapping and hunting began to show up in the area around the Reserve soon after the Americans took over the territory after the War of 1812. By this time elk, moose, and beaver were largely eradicated from the region, and deer were significantly decreased in numbers (Cole 1918; Schoolcraft 1953).

The dominant Indian tribe that occupied the area around the Leopold Reserve at the time of the arrival of European explorers was the Winnebago. The Winnebago made their living by farming and hunting and lived in permanent villages. Two of their villages were in Baraboo and Wisconsin Dells. An Indian path from the village in the Dells traversed the Reserve (Brink 1845). The Winnebago used fire to make good pasture for deer, to drive game, to provide for a renewed growth of blueberries and huckleberries, and for communication (Quimby 1960; Peske 1971; Lange 1976; Dorney 1981).

On a journey from Green Bay to St. Louis in 1821, the Green Bay pioneer, Ebenezer Childs, saw "but seven white men in the whole distance, outside the forts" (Childs 1859). Europeans were moving into the area, however, making the local Winnebago Indians restless. To keep the tribe in check, the American government built Fort Winnebago in 1828 near what is now Portage (Prucha 1964). The temporary barracks were constructed of pine logs obtained from an area known as Pine Island about six miles west of Portage (Turner 1898), which was in the close vicinity of the Reserve. In describing the "portage" during a trip through Wisconsin in 1835, the English scientist Featherstonaugh made this prophetic remark:

> [The portage was covered with] tall wild grass, no longer kept cropped by roving buffaloes, which had been driven beyond the Mississippi. . . . It could not be long before the Indians will go the way of the buffalo, and cultivated grasses replace the native one. . . . The scythe of what is called "civilization" is in motion, and everything will fall before it. (Featherstonaugh 1847)

Two years later the Winnebago Indians ceded their land to the United States government, thereby allowing permanent settlement of the region (Gregory 1932).

Pioneer Era (1837–1865)

The Pioneer era was a transitional one, during which the first pioneers settled and began to farm what is now the Leopold Memorial Reserve. These pioneer farmers, mostly native-born Yankees (Canfield 1861a; Cole 1918), allowed their livestock to run at large and placed fences around their cropland (Gregory 1932). Wildfires were common, especially in the springtime (Gregory 1932). The frontier was pushing westward, with thousands of immigrants using an early state road (now Levy Road) that traversed the Reserve following the original Indian path (Cole 1918; Davis 1947). The cutting of the Wisconsin Pinery north of Wisconsin Dells was in full swing, with "almost a constant run" of log rafts down the Wisconsin River from early spring till early fall (*Wisconsin Power Service Commission v. Federal Power Commission,* Transcript of Record, 1944).

At the time of European settlement of the Reserve area in the early 1840s, the vegetation of the Reserve was an open, fire-maintained mosaic of oak savanna (38% by relative area coverage), floodplain forest (33%), marshland (27%), and upland forest (2%) (Table 1).

Traveller, surveyor, and pioneer accounts provide differing pictures of the vegetation of the area. While surveying the Leopold Marsh, John Brink wrote in his field notes: "Land Level wet and sandy (Quick Sand) 3rd Rate—Black & Yellow Oak and not much of that—Marsh bad enough and good for nothing" (Brink 1845). In contrast, a Gazetteer used to attract immigrants to Wisconsin gave the following general description of the area (Hunt 1853):

> The openings, which comprise a large portion of the finest land of the state, owe

Table 1. Relative area coverage of the plant community types in what is now the Leopold Memorial Reserve, Sauk County, Wisconsin, during the 1840s, the 1930s, and the 1970s.

Plant Community Type	% of total land surface during the 1840s	% of total land surface during the 1930s	& of total land surface during the 1970s
Marsh	27	30	23
Aquatic	(1)	(1)	(2)
Emergent Aquatic	(3)	(3)	(2)
Sedge Meadow	(15)	(10)	(7)
Wet Meadow	(0)	(3)	(4)
Low Prairie	(8)	(2)	(0)
Shrub-carr	(0)	(11)	(8)
Floodplain Forest	33	24	26
Mixed F. Forest	(31)	(22)	(24)
Wet F. Forest	(2)	(2)	(2)
Savanna	38	10	6
Oak Opening	(31)	(2)	(0)
Oak Barrens/Dry Meadow	(7)	(8)	(6)
Upland Forest	2	19	34
Mixed Hard. Forest	(1)	(1)	(7)
Dry Upland Forest	(1)	(18)	(27)
Disturbed Areas	0	17	11
Roadsides	(0)	(1)	(1)
Cultivated Fields	(0)	(16)	(10)

their present condition to the action of the annual fires which have kept under all other fast growth, except those varieties of oak which can withstand the sweep of that element.

This annual burning of an exuberant growth of grasses and of underbrush, has been adding, perhaps for ages, to the productive power of the soil, and preparing it for the plough-share.

It is the great fact, nature has thus "cleaned" up Wisconsin to the hand of the settler, and enriched it by yearly burnings, and has at the same time left sufficient timber on the ground for fence and firewood, that explains, in a great measure, the capacity it has exhibited, and is now exhibiting for rapid settlement and early maturity.

There is another fact important to be noticed in this connection. The low level prairie, or natural meadow, of moderate extent, is so generally distributed over the face of the county, that the settler on a fine section of arable land, finds on his own farm, or in his immediate neighborhood, abundant pasturage for his stock in summer, on the open range; and hay for the winter, for the cutting—the bounty of nature supplying his need in this behalf, till the cultivated grasses may be introduced and become sufficient for his use.

In 1843, Amos Anderson, a native of Norway, settled on the western end of the Leopold Reserve, preparing the ground that year for crops that gave him profitable returns in the following year

(Gregory 1932). He was the first settler in Fairfield Township. Although most of the land within the Reserve passed into private hands by the early 1850s, it was not actively farmed but rather was held onto for a year or more, possibly for speculative purposes, and then sold. By 1854, virtually all of the Reserve lands were being actively farmed.

These pioneer farmers only had about 30 acres under the plow, the rest being used as open range for sheep and cattle. The areas put under cultivation included the "Shack" and "Coleman" prairies (Fig. 2). Corn, wheat, and oats were the primary crops, produced in approximately equal quantities. The principal market was the Pinery (Staines 1852).

Wildfires were common during the 1840s and 1850s, especially in the springtime, but diminished thereafter as the area became settled (Gregory 1932). In the early 1860s, after the cessation of wildfires, pines began to germinate in the "Anchor" woods of the floodplain forest (Leopold 1942) (Fig. 2).

Farming Era (1866–1934)

In southcentral Wisconsin, the Farming era began for both man and wildlife as a time of plenty, but ended for both as a time of devastation. Soldiers returning from the Civil War in the late 1860s placed the remaining fertile land under cultivation (Scott 1980). These farmers cultivated the rolling upland savannas, left the ridge savannas to succeed into forest, and burned off the marshlands for mowing of the marsh hay. A 1870 law, forbidding farmers from allowing their livestock to run at large, stopped indiscriminate grazing but intensified grazing in certain areas (Schafer 1922). The resulting mixture of fields, brushlands, and marshlands created excellent conditions for wildlife. Leopold (1934) described it this way:

> The optimum conditions for game came after settlers had begun to farm the surrounding hill country. The settlers burned large openings in the tamaracks and used them as hay meadows. Every farmer who owned a quarter-section in the hills also owned a forty in the marsh, where he repaired every August to cut his hay. In winter, when frost had hardened the marsh, he hauled the hay to his farmstead.
>
> The open haymeadows, separated by stringers of grass, oak, and popple, and by occasional remnants of tamarack, were better crane, duck, and sharptail range than the primeval bogs. The grain and weeds on the farms abutting the marsh acted as feeding stations for prairie chickens, which soon became so abundant as to take a considerable part of any grain left in the fields. These were the golden days of wildlife abundance. Fires burned parts of the marsh every winter, but the water table was so high that the horses had to wear "clogs" at mowing time, hence no fire ever "bit" deep enough to do any lasting harm.

However, by 1890, after all the fertile uplands were under cultivation, farmers made attempts to crop the marshland in dry years. The first results were bountiful beyond reason and agriculture started with a rush. The marshland fertility unfortunately quickly disappeared and an added succession of wet years reduced the farmers to desperation. To rehabilitate these farmers Wisconsin passed the Drainage Law of 1894, which provided an incentive to restore wetlands to agriculture through ditching and draining (Wisconsin Regional Planning Committee 1934). Now during dry years the exposed peat itself began to burn, rendering cultivation impossible (Leopold 1934). In addition, the meager natural fertility of the upland sandy meadows was depleted. By the 1930s many farms were abandoned in the "sand counties" to brush and weeds, wind and weather (Wisconsin Regional Planning Committee 1934).

Farming activity on the Leopold Memorial Reserve closely followed this regional scenario (see Fig. 2 for the locations on the Reserve of the parcels discussed in this section). During the late 1860s and 1870s most of the fertile land, now part of the Reserve, was being farmed. For the remainder of the century, the cultivated land included practically all of the rolling uplands with the addition of the "Shack" prairie and the "Coleman" prairie. Most of the marsh, except the wetter portion of the "great marsh" southeast of Chapman Lake, was being mowed for marsh hay, with intermittent fires being set to stimulate production. The oak opening and low prairie around present day Turner Pond and the floodplain forest were grazed, encouraging the spread of thorny shrubs. The ridges succeeded into forest in the absence of fire and grazing, probably remaining undisturbed until intensive cutting for firewood began in the late 1800s. In the mid-1880s, the clearings within the "Anchor" woods and "Susan's savanna" were brought under cultivation. Around the turn of the century, the "Draba" prairie was brought under cultivation, and the "Coleman" prairie was abandoned. Farms were diversified with the most important crops being corn, oats, spring wheat, and potatoes. Sheep were the most important animal stock.

Equally dramatic changes occurred on the Leopold Reserve lands in the early 1900s. Between 1910 and 1920, farmers dug drainage ditches across the "long marsh" west of Chapman Lake. In the 1920s, cultivation of the riverbottom openings ceased. Grazing of the wetlands east and west of what is now the Terbilcox house began. In the late 1920s, the "island" north of the Shack, currently part of the mainland, was logged. The marsh burned for the last time. In the early 1930s, the "Shack" prairie was abandoned. Unfortunately, the agricultural census records covering much of this period were destroyed in a fire, making it impossible to reconstruct the precise record of cultivation.

Leopold Era (1935–1949)

The Leopold era was a transition between older farming practices and modern mechanized agriculture, and the beginning of a land restoration movement. The depression and drought of the 1930s had taken their toll on the Reserve lands, with one farm being abandoned, the house burned down, and the property falling into the hands of the county. Aldo Leopold purchased this property in 1934; his friend Tom Coleman purchased an adjacent farm in 1937 (Fig. 2). With their purchases began a new attitude toward the land, whereby landowners started to reverse the process of land deterioration and to build it back to something like its pre-settlement condition. Toward the end of this era, new farming practices, particularly the use of tractors, made mowing the marsh hay or cultivating the small floodplain openings mechanically difficult and economically unfeasible. This, in turn, presaged the end of farming in the area.

About the time Leopold purchased his land, what is now the Leopold Memorial Reserve was still a relatively open, farming-maintained mixture of marshland (30% by relative area coverage), floodplain forest (24%), upland forest (19%), agricultural fields (17%), and oak savanna (10%) (Table 1). Leopold (1949) provides a description of the area:

> My own farm was selected for its lack of goodness and its lack of highway; indeed my whole neighborhood lies in a backwash of the River Progress. My road is the original wagon track of the pioneers, innocent of grades or gravel, brushings or bulldozers. My neighbors bring a sigh to the County Agent. Their fencerows go unshaven for years on end. Their marshes are neither

dyked nor drained. As between going fishing and going forward, they are prone to prefer fishing.

During the majority of Leopold's tenure on the Reserve, the floodplain forests were grazed but the upland forests were not (Leopold 1942; Liegel 1981) (see Fig. 2 for the locations on the Reserve of the parcels discussed in this section). The abandoned fields began to succeed back into prairie. The pines in the "Anchor" woodland were cut. The marsh areas were mowed until the mid-1940s when tractors became common among farmers on the Reserve. Grazing of the wetlands east and west of what is now the Terbilcox residence ended. Grazing of the "Kammerer meadow" began. Shrubs began to slowly invade the wetlands margins when cultivation and mowing ceased, fanning out particularly from the drainage ditch south of "long marsh."

Almost immediately after purchase of their farm, the Leopold family began the planting of thousands of native trees, particularly pines, and woodland shrubs and wildflowers (Leopold 1935–1949). Virtually all of the plantings from 1936 to 1938 died because of drought (Leopold 1936, 1937), but the family persisted and by the early 1940s the Shack was surrounded by young pine seedlings. In the late 1930s Leopold began to transplant prairie plants into the field in front of the Shack, a process which continued until his death in 1949. However, he did not burn the "Shack" prairie.

Agricultural Era (1950–1967)

Commercial farming for all practical purposes ended on the Leopold Memorial Reserve during the Agricultural era. The Reserve farms were simply too small, too infertile, and too varied in their soils and topography to lend themselves to modern farming techniques and the use of tractors and commercial fertilizers. Gentleman farmers, who for the most part rented out the larger and more fertile fields, replaced the older farmers throughout the Reserve. Shrubs and trees quickly invaded the riverbottom forests and marshlands when grazing and mowing ceased.

Farmer attrition occurred throughout the 1950s and 1960s (see Fig. 2 for the locations on the Reserve of the parcels discussed in this section). In 1947 Carl Anchor moved his house out of the Reserve. In 1955 Howard Kammerer purchased a farm, allowing only intermittent grazing of the riverbottom forest and of the "Kammerer meadow" just east of the farmhouse. In 1956 Russ Van Hoosen inherited a farm, ending grazing of his property. In 1957 Frank Terbilcox purchased a farm, ending grazing of his property. In the early 1960s the construction of the interstate highway put an end to the agricultural use of the Sinner Property. In 1961 Charles Anchor inherited a farm and ended all agricultural activity. In 1962 Ray Turner ended grazing of the wetland shrub carr around present day Turner Pond.

The ending of agricultural activity on the Reserve lands began to have a dramatic effect on its character and ecology. The previously cultivated fields continued their succession into prairie. Prickly ash *(Xanthoxylum americanum)* began to fill in the previously open mixed floodplain forest and floodplain oak barrens. The wetland margins continued to succeed into shrub carr. And the shrub carr succeeded on low prairie sites into mixed hardwood forest.

With the death of Aldo Leopold in 1949 and the movement of his family away from Wisconsin, the restoration of the Leopold property ceased. The 1950s and 1960s were quiet times with little visitation and almost no management. In 1967 the Leopold family deeded the property to what is now the Aldo Leopold Shack Foundation. They established this family foundation in order to provide for maintenance of the Shack, not only for their own use but as a laboratory for continued ecological and restoration studies.

Leopold Reserve Era (1968–present)

The Aldo Leopold Memorial Reserve was created in 1968 as a cooperative private wildlife preserve memorializing Aldo Leopold. In response to a growing threat of recreational development in the Baraboo area, Reed Coleman, the son of Leopold's good friend and neighbor Tom Coleman, persuaded the other landowners surrounding the Leopold tract to pool their properties under common management funded by what is now the Sand County Foundation. The five landowners who cooperated in this private preserve were Reed Coleman, Franklin Terbilcox, the Leopold family, Russell Van Hoosen, and the Sand County Foundation. Robert Ellarson, one of Leopold's students, drafted a generalized management plan. Terbilcox accepted the job of Reserve Manager.

During the subsequent years, the Sand County Foundation began purchasing some of the adjoining properties. The Foundation purchased the Sinner Property in 1968, part of the Turner Property and the "island" in 1970, the Anchor Property in 1972, the Kammerer Property in 1977, the Ragan Property in 1982, and another parcel of the Turner Property in 1982 (Fig. 2).

With the creation of the Aldo Leopold Memorial Reserve, Leopold's land rehabilitation program of the 1930s and 1940s was continued and expanded to include the entire Reserve. The focus of the early to mid-1970s was predominantly on wildlife management. Reserve Manager Terbilcox cleared a network of trails, dug a number of duck ponds (Turner and Van Hoosen ponds, 1969–1970; Center pond, 1977), planted "wildlife patches" around the ponds and in part of the "long marsh" west of Chapman Lake, occasionally mowed the "long marsh," and burned the "Shack" and "Coleman" prairies (Fig. 2).

In 1976, eight years after the Reserve was established, Charles and Nina Leopold Bradley retired on the Reserve and began a student research program for ecological studies of the area. The Bradleys built the Study Center, with a laboratory and work area in the lower level (Fig. 2). The first Leopold fellows created a working base map and started a comprehensive inventory of the Reserve, including plants and plant communities (Luthin 1978; 1979; 1980), land-use and vegetational history (Liegel 1982; and the present report), palynology (Winkler 1985), glacial geology (Socha 1984), soils (Sharp and Bowles 1985), hydrology (Zolidis 1985), birds (Mossman and Reed 1978), and wildlife (Mossman 1980; Tohulka 1979).

During the late 1970s and up to the present, the focus of management efforts has been more on restoring and maintaining native plant community types once more common on the Reserve. Management efforts have included restoration of old fields into prairie, brush management in the low prairie and oak barrens, and thinning of the Leopold pines.

Today the Leopold Memorial Reserve is a relatively closed combination of upland forest (34% by relative area coverage), floodplain forest (26%), marshland (23%), oak savanna (6%), and cultivated fields (11%) (Table 1).

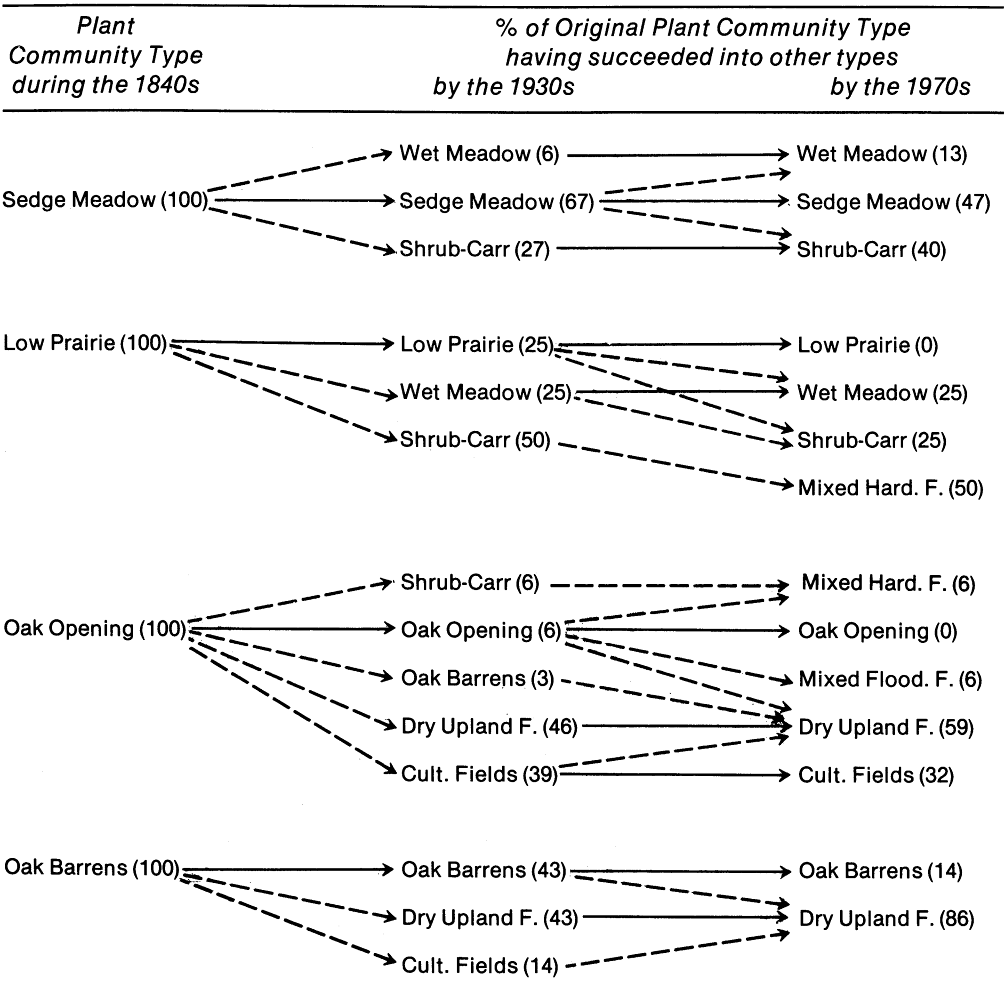
Vegetational Change Following European Settlement

The preceding land-use chronology displays the panorama of vegetational change that has occurred on the Leopold Memorial Reserve during the last 13,000 years. The vegetation maps of the 1840s, 1930s, and 1970s, to be examined in this section, show more graphically the precise changes in percentage land cover by different plant community types since settlement, and the land-use factors responsible for these changes.

Ten natural and three disturbed vegetation types were identified as comprising the vegetation of the Leopold Memorial Reserve in the 1840s, 1930s, and 1970s (Fig. 3–Fig. 5). The relative area covered by each vegetation type for the different time periods is given in Table 1. Successional trends for selected plant community types between 1840 and 1980 are shown in Table 2. The characteristics of each community type are given in Table 3.

As previously discussed elsewhere (Liegel 1982), three interdependent factors seem to have been crucial in influencing the pattern and composition of the presettlement vegetation types on the Re-

Table 2. Successional trends in selected plant community types on what is now the Leopold Memorial Reserve, Sauk County, Wisconsin, between 1840 and 1980.



serve: topography, hydrology, and fire. Four land-use factors seem to have been crucial in influencing the pattern and composition of the post-settlement vegetation types on the Reserve: fire control, grazing, mowing, and cultivation. The probable role of these land-use factors in vegetational change on the Reserve will be analyzed by examining successional trends in the following community types: (1) oak opening, (2) oak barrens, (3) sedge meadow, and (4) low prairie.

Oak Opening to Upland Oak Forest

Oak opening was the dominant plant community type on the Leopold Reserve at the time of settlement, covering almost one-third of the total land surface (Fig. 3;

Table 3. Characteristics of the plant community types on the Leopold Memorial Reserve, Sauk County, Wisconsin.

Plant Community Type	*Ecological Characteristics*
Aquatic	Continuous standing water at least 12″ deep, dominated by submerged aquatics
Emergent Aquatic	Shallow standing water through much or all of the growing season, dominated by cattail *(Typha latifolia)* and river bulrush *(Scirpus fluviatilus)*
Sedge Meadow	Saturated organic soils, dominated by sedges (*Carex* spp.)
Low Prairie	Grassland commonly inundated in the spring, dominated by big bluestem *(Andropogon gerardi)*, bluejoint *(Calamagrostis canadensis)* and cordgrass *(Spartina pectinata)*
*Wet Meadow	Disturbed sedge meadow, pastured low prairie, or weed community found on man-made pond spoils
*Shrub Carr	Shrubland dominated by shrubs or early-successional trees, such as aspen *(Populus tremuloides)*
Wet Floodplain Forest	Forest found along sloughs and old river channels, dominated by silver maple *(Acer saccharinum)*
Mixed Floodplain/ Mixed Hardwood Forests	Lowland forest dominated by river birch *(Betula nigra)*, ashes (*Fraxinus* spp.), prickly ash *(Xanthoxylum americanum)*, *(Pinus strobus)*, and, in mixed hardwood forest, by aspen *Populus tremuloides)*
Oak Opening	Savanna dominated by bur *(Quercus macrocarpa)* and white oak *(Q. alba)*
Oak Barrens	Savanna dominated by black oaks *(Quercus velutina, ellipsoidalis,* and *rubra)*, and, in the floodplain, by prickly ash *(Xanthoxylum americanum)*
*Dry Meadow	Former savanna disturbed by cultivation and/or grazing, dominated by Eurasian grasses and native prairie species
Dry Upland Forest	Forest dominated by oaks (*Quercus* spp.), black cherry *(Prunus serotina)*, and locally white pine *(Pinus strobus)*
*Roadsides	Composed primarily of hardy disturbance-resistant perennials, often of Eurasian origin
*Cultivated Fields	Agricultural fields subject to seasonal disturbance, dominated by annuals
	* man-induced plant communities

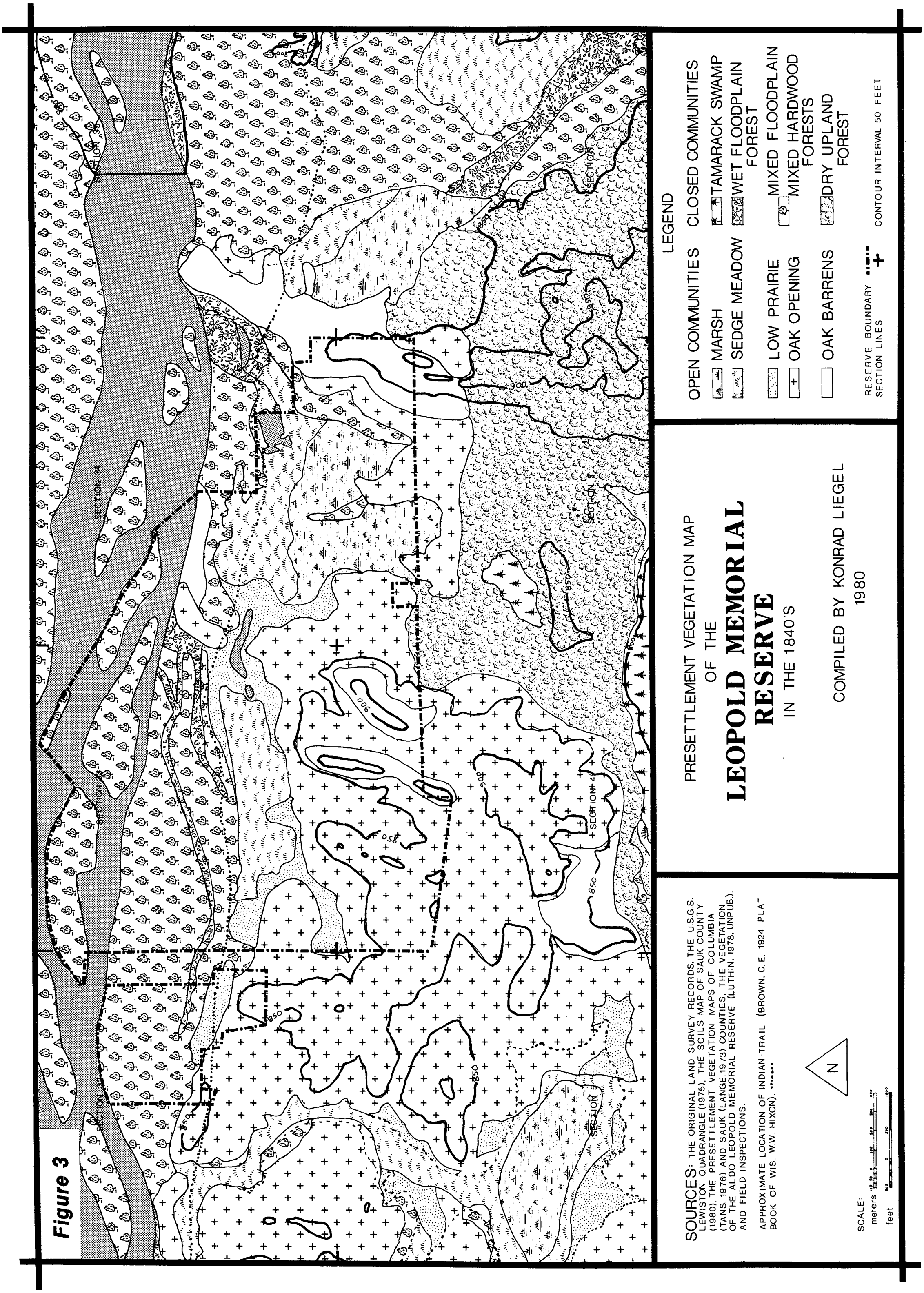


Figure 3
PRESETTLEMENT VEGETATION MAP
OF THE
LEOPOLD MEMORIAL
RESERVE
IN THE 1840'S
COMPILED BY KONRAD LIEGEL
1980
LEGEND
OPEN COMMUNITIES
MARSH
SEDGE MEADOW
LOW PRAIRIE
OAK OPENING
OAK BARRENS
CLOSED COMMUNITIES
TAMARACK SWAMP
WET FLOODPLAIN FOREST
MIXED FLOODPLAIN
MIXED HARDWOOD FORESTS
DRY UPLAND FOREST
RESERVE BOUNDARY
SECTION LINES
CONTOUR INTERVAL 50 FEET
SOURCES: THE ORIGINAL LAND SURVEY RECORDS, THE U.S.G.S. LEWISTON QUADRANGLE (1975), THE SOILS MAP OF SAUK COUNTY (1980), THE PRESETTLEMENT VEGETATION MAPS OF COLUMBIA (TANS, 1976) AND SAUK (LANGE, 1973) COUNTIES, THE VEGETATION OF THE ALDO LEOPOLD MEMORIAL RESERVE (LUTHIN, 1978, UNPUB.) AND FIELD INSPECTIONS.
APPROXIMATE LOCATION OF INDIAN TRAIL (BROWN, C.E. 1924, PLAT BOOK OF WIS. W.W. HIXON).
N
SCALE:
meters
feet
SECTION 34
SECTION 33
SECTION 3
SECTION 4
SECTION 5
850
900

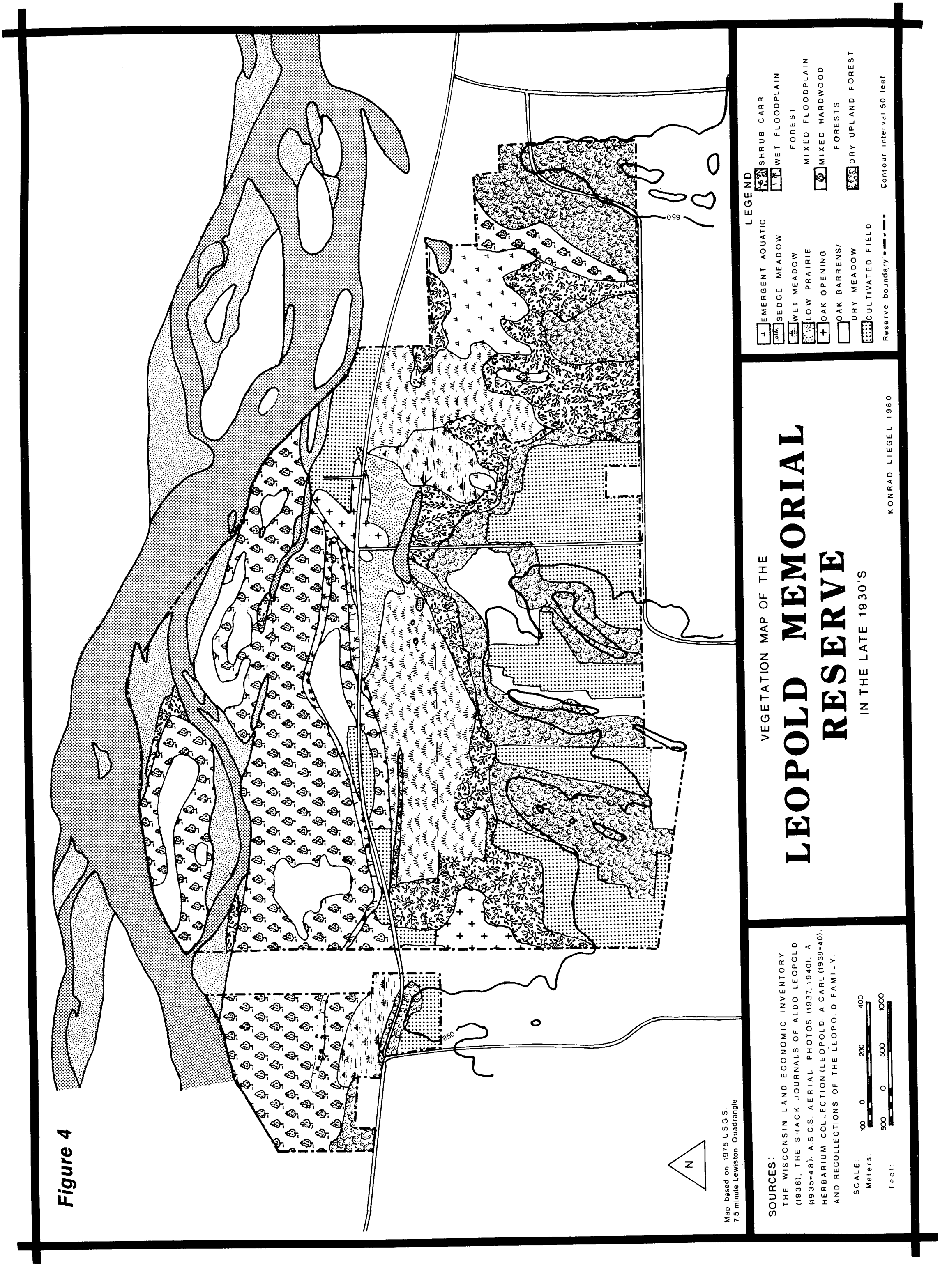

VEGETATION MAP OF THE
LEOPOLD MEMORIAL RESERVE
IN THE LATE 1930'S
KONRAD LIEGEL 1980
LEGEND
EMERGENT AQUATIC
SEDGE MEADOW
WET MEADOW
LOW PRAIRIE
OAK OPENING
OAK BARRENS/ DRY MEADOW
CULTIVATED FIELD
SHRUB CARR
WET FLOODPLAIN FOREST
MIXED FLOODPLAIN
MIXED HARDWOOD FORESTS
DRY UPLAND FOREST
Reserve boundary
Contour interval 50 feet
SOURCES:
THE WISCONSIN LAND ECONOMIC INVENTORY (1938), THE SHACK JOURNALS OF ALDO LEOPOLD (1935-48), A.S.C.S. AERIAL PHOTOS (1937, 1940), A HERBARIUM COLLECTION (LEOPOLD, A. CARL (1938-40), AND RECOLLECTIONS OF THE LEOPOLD FAMILY.
SCALE:
Meters: 100 0 200 400
Feet: 500 0 500 1000
Map based on 1975 U.S.G.S.
7.5 minute Lewiston Quadrangle
N

Figure 4

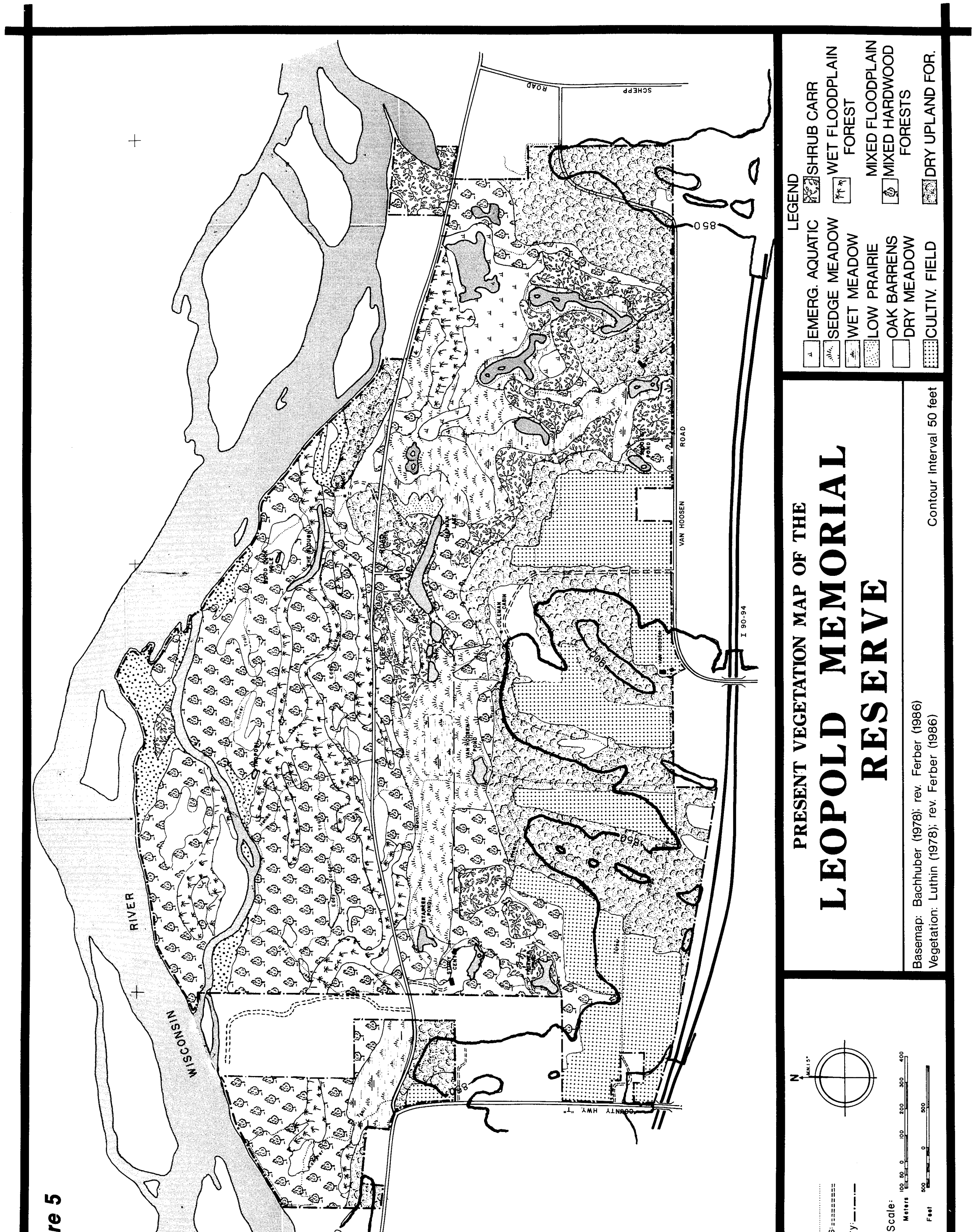


Figure 5
PRESENT VEGETATION MAP OF THE
LEOPOLD MEMORIAL
RESERVE
Basemap: Bachhuber (1978); rev. Ferber (1986)
Vegetation: Luthin (1978); rev. Ferber (1986)
Contour Interval 50 feet
LEGEND
EMERG. AQUATIC
SEDGE MEADOW
WET MEADOW
LOW PRAIRIE
OAK BARRENS
DRY MEADOW
CULTIV. FIELD
SHRUB CARR
WET FLOODPLAIN FOREST
MIXED FLOODPLAIN
MIXED HARDWOOD FORESTS
DRY UPLAND FOR.
Legend
Trails:
Dirt roads:
Reserve boundary:
Scale:
Meters
Feet
WISCONSIN
RIVER
VAN HOOSEN ROAD
SCHEPP ROAD
I 90-94
COUNTY HWY. "T"
850
900

Table 1). Today dry upland oak forest is the dominant plant community type of the Reserve; oak opening with an intact natural groundlayer is no longer present (Table 2).

After settlement, the rolling upland oak openings, which comprised about 40% of the oak openings, were cultivated. Most of the rolling upland oak openings remained under cultivation (Table 2). Meanwhile, virtually all of the ridge oak openings, which comprised about 50% of the oak openings, quickly succeeded into dry upland oak forest, due to the absence of fire and grazing. Thereafter, the oak forests were occasionally but never intensively grazed, and were also selectively cut for firewood. They remain dry upland oak forest today (Table 2). Finally, the lowland oak openings, which comprised about 10% of the oak openings, succeeded into shrub carr or were maintained by grazing until the early 1950s. Grazing may have maintained the lowland oak openings, but it destroyed the natural groundlayer. The lowland oak openings are mixed hardwood forest today (Table 2).

Floodplain Oak Barrens to Cultivated Fields to Floodplain Oak Barrens/Upland Oak Barrens to Dry Upland Oak Forest

Oak barrens were scattered on sandy sites throughout the Leopold Reserve at the time of settlement, occupying about 12% of the total land surface (about 5% of which is labelled as mixed floodplain forest in the 1840s map) (Fig. 3; Table 1). Today virtually all of the original floodplain oak barrens remain oak barrens, while 86% of the original upland oak barrens has succeeded into dry/upland forest (Table 2).

The floodplain oak barrens were for the most part cultivated after settlement, but were abandoned several decades later when the meager natural soil fertility ran out (Fig. 4). After abandonment, these "dry meadows" began to succeed back into a dry-mesic prairie, and now are oak barrens again. However, unlike the original floodplain oak barrens, today's floodplain oak barrens are invaded by prickly ash *(Xanthoxylum americanum)*. The ridge oak barrens, meanwhile, succeeded into dry upland black oak forest, due to the absence of fire and grazing, but at a slower rate than the ridge oak openings (Table 2). Unlike the white oak forest formed from former ridge oak openings, the dry upland black oak forest maintained an intact natural groundlayer, presumably because of the relatively open canopy and infertile soils (Curtis 1959; Vogl 1964). Therefore, the dry upland black oak forest on the Reserve easily lends itself to restoration, as demonstrated in the restoration of "Frank's" prairie (Holtz and Howell 1983) (Fig. 2).

Sedge Meadow to Wet Meadow and Shrub Carr

Sedge Meadow occupied about 15% of the total land surface of the Leopold Reserve at the time of settlement (Fig. 3; Table 1). Today about half of the original sedge meadow remains, the remaining half having succeeded into shrub carr or a disturbed version of the sedge meadow community known as wet meadow (Table 2).

Most of the sedge meadow on the Reserve was maintained from settlement through the mid-1940s by the periodic mowing of marsh hay. The remainder of the sedge meadow succeeded into shrub carr and wet meadow (Fig. 4). When mowing of the sedge meadows ceased in the 1940s, succession into shrub carr accelerated (Fig. 5). Drier hydrologic conditions, resulting from groundwater movement away from the marsh and toward the drainage ditch and from changes in river morphology, most likely also contributed to this successional trend (Bedford et al. 1974).

Stevens (1985) utilized the 1937 to 1975 aerial photographs to analyze the rates of shrub invasion on Reserve sedge meadow over time. Shrub cover increased in "long marsh" from 27% in 1937 to 50% in 1966 with a slight decrease due to mowing in 1955. South of the drainage ditch, the change was even more dramatic, with shrub cover increasing from 35% in 1937 to 83% in 1977.

Low Prairie to Shrub Carr to Mixed Hardwood Forest

Low prairie occupied about 8% of the total land surface on the Leopold Reserve at the time of settlement (Fig. 3; Table 1). Today, the low prairie has virtually disappeared as a community type on the Reserve, having been replaced by wet meadow, shrub carr, and mixed hardwood forest (Table 2).

In the absence of fire or mowing, or in the presence of grazing, about half of the original low prairie succeeded into shrub carr by the 1930s (Fig. 4) and ultimately into mixed hardwood forest thereafter (Fig. 5). Mowing delayed this succession in the low prairie near Chapman Lake (Stevens 1985) (Fig. 3–Fig. 5). When mowing ended in the late 1930s, shrubs quickly invaded, increasing from 17% in 1937 to 40% in 1949 but remaining constant until 1975 due to infrequent mowing. In 1975, shrub cover had reached 61% and has continued to increase ever since due to lack of mowing and burning.

Summary

The changes in vegetation on the Leopold Memorial Reserve since glaciation have been dramatic. The proglacial boreal forest and sphagnum bog communities of approximately 12,000 years ago have given way to the fire-maintained, relatively open oak savanna, marshland, and floodplain forest communities of pre-European settlement Wisconsin. These aboriginally influenced communities, in turn, have given way to the agriculturally influenced, relatively closed oak forest, shrub carr, cultivated field, and floodplain forest communities of today.

The character and appearance of the landscape of the Leopold Reserve has changed significantly since European settlement. At the time of settlement, two-thirds of the Reserve lands were composed of open communities of savanna and marshland; today, two-thirds of the Reserve is composed of closed communities of upland oak forest, mixed floodplain forest, and shrub carr. The primary factor responsible for this change is the control of fires that resulted from lightning strikes and Indian activities.

Agricultural use of the area helped to delay this succession of open communities into closed ones. Grazing and cultivation kept the savannas open but destroyed the natural groundlayer. The mowing of marsh hay, meanwhile, kept the low prairie and sedge meadow open. Agricultural use probably peaked in the 1920s, dropped throughout the 1930s, 1940s, and 1950s, and then leveled off in the 1960s. This decline in agriculture was due to the meager natural fertility of the soil, the introduction of modern mechanized farming, and farmer attribution.

Reflecting over the immense changes that had occurred since European settlement, an early pioneer of the township lamented in these somewhat florid words:

> Fairfield in pioneer days was a veritable flower garden. Wherever the sod was unbroken the ground was literally covered with flowers. It was a delight to look upon them and think that God and not man nor woman planted them and that Solomon in all his glory was not arrayed like one of these. There was one variety for which I looked in vain, the dandelion. The dear home flower, how I missed it and longed for the sight of it. The 2nd or 3rd year my sister, who was always looking for it as well as I, found just one and Mrs. Wing laugh-

ingly tells the story of Mrs. Emily how finding a dandelion and being so overjoyed that she shed tears. Neither was there a stalk of mullein to be seen in all the land. But we said: "with the coming of the sheep the mullein will grow," which has passed true and the time has come when we could dispense with the everlasting presence of both dandelion and mullein. (Luce 1912)

Acknowledgments

Many persons deserve special thanks for helping with this project. In particular, I wish to acknowledge the help the late Walter E. Scott gave in sharing with me his insights about the land-use history of the region and his extensive library of materials on Wisconsin. I also wish to thank Evelyn Howell (Department of Landscape Architecture, University of Wisconsin-Madison) and Kenneth I. Lange (Naturalist, Devil's Lake State Park) for their advice and editorial suggestions, my wife Karen Atkins for her assistance with producing the maps and figures, and Nina and Charles Bradley for their graciousness and generosity. I am also grateful to the Sand County and Aldo Leopold Shack Foundations; without their financial support during my four years of fellowship studies on the Leopold Reserve, I cound not have completed my studies.

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Collections of young-of-the-year Blue Suckers *(Cycleptus elongatus)* in Navigation Pool 9 of the Upper Mississippi River

Michael C. McInerny and John W. Held

Abstract. *Ten young-of-the-year blue suckers* (Cycleptus elongatus) *were collected in July 1979 and June 1980 from intake screens of a steam-electric station located on the east shore of Navigation Pool 9 (River Mile 678.5) of the Mississippi River. These blue suckers probably hatched in early May and may have been reared in the tailrace below Lock and Dam No. 8.*

The blue sucker *(Cycleptus elongatus)* is rare but widespread in the Missouri and Mississippi Rivers and their tributaries (Pflieger 1975). Dam construction resulting in reduced current velocity, increased siltation, and barriers to spawning migrations was thought to be responsible for the decline of this once abundant species (Cross 1967; Pflieger 1975). Blue suckers are rare in Wisconsin and are classified by the state as a threatened species (Wis. Dep. Nat. Resour. 1987). Johnson (1987) listed the blue sucker as a species of special concern in Minnesota. In Wisconsin, blue suckers are limited to the Mississippi River drainage (Becker 1983). Rasmussen (1979) reported that collections of blue suckers in Navigation Pool 9 of the Upper Mississippi River were rare between 1969 and 1979, but they were not collected in adjacent Pools 8 and 10. Blue suckers in Pools 8 and 10 had been collected before 1969.

Information on the life history of blue suckers is limited. Rupprecht and Jahn (1980) presented data on growth, food habits, and spawning in Navigation Pool 20 of the Mississippi River, and Moss et al. (1983) provided similar information for the Neosho River, Kansas, plus data on habitat use by all life stages except larvae. We report collections of young-of-the-year blue suckers from Navigation Pool 9 of the Mississippi River.

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John W. Held is a Professor of Biology and Microbiology at the University of Wisconsin-La Crosse.

Methods and Materials

Weekly 24-hr samples of fishes were collected from intake screens of Dairyland Power Cooperative's Genoa #3 steam-electric station from August 1978 through June 1980. Descriptions of the collection baskets used are described in McInerny (1980). Although not a traditional sampling gear, intake screens are practical and useful for qualitatively sampling fish populations in the vicinity of the intakes (Margraf et al. 1985). All fish collected were identified to species, measured (total length in mm), counted, and weighed (g).

Genoa #3, a coal-fired steam-electric station (350 MWe) is on the east shore of Navigation Pool 9 of the Mississippi River (River Mile 678.5) approximately 0.8 km downstream of Lock and Dam No. 8 and 1.2 km south of Genoa, Wisconsin. The intake structure of Genoa #3 was constructed along a rip-rap shoreline that extends from Lock and Dam No. 8 to approximately 0.8 km downstream of the steam station. The rip-rap generally consisted of large (>250-mm diameter) rocks.

River water temperatures on each sample day were obtained from plant personnel at Genoa #3. Current velocity at the surface was determined by measuring the time required for a semi-bouyant float to move a fixed distance. River discharge data at Lock and Dam No. 8 during sampling were obtained from the U.S. Army Corps of Engineers.

Results and Discussion

One blue sucker, 67 mm TL, was collected on the intake screens on 16 July 1979. Water temperature was 23°C and river discharge was 83,000 m^3/min. Nine blue suckers, ranging from 37 to 53 mm TL, were collected on 25 June 1980; water temperature was 22°C and river discharge was 50,000 m^3/min. Current velocity averaged 0.3 m/s at the shoreline and 0.8 m/s 20 m from shore. Current along the rip-rap shoreline in the vicinity of the intake screens presumably attracted these young-of-the-year blue suckers. Moss et al. (1983) reported that juvenile blue suckers in the laboratory preferred smooth substrates of fine gravel (>2 mm), large cobble (>128 mm) or bedrock (>256 mm) and preferred the strongest current (1 to 1.2 m/s).

We estimated that these blue suckers hatched in early May each year. These estimations were based on mean lengths of larval blue sucker at hatching (8.7 mm), and growth rates of 0.5 mm/da for larvae <23 mm TL and ~1 mm/da for larvae ≥23 mm (Semmens 1985). Water temperatures in late April/early May were 13 to 14°C, within the range (13 to 17°C) that Rupprecht and Jahn (1980) observed turberculated male blue suckers in obvious spawning condition (free-flowing milt) at Navigation Pool 20 of the Mississippi River. Larval catostomids were collected on 18 June 1979 and weekly from 20 May through 19 June 1980, but were identified only to family (McInerny 1980). Additional collections of larvae in Navigation Pool 9, along with improvements on identification of larval blue suckers (Yeager and Semmons 1987), could demonstrate that the tailrace of Lock and Dam No 8 is used by blue suckers for spawning and rearing of young. This information could be crucial for maintaining this species in Wisconsin.

Acknowledgment

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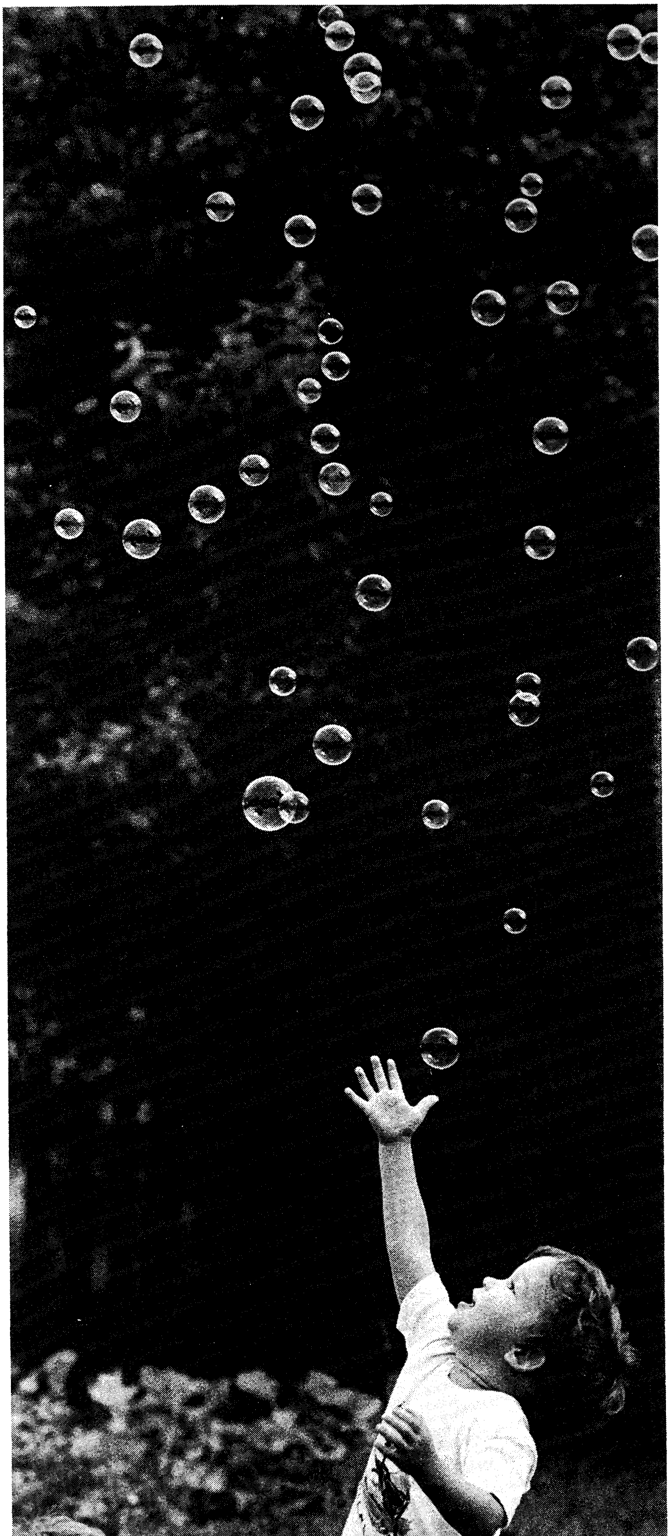
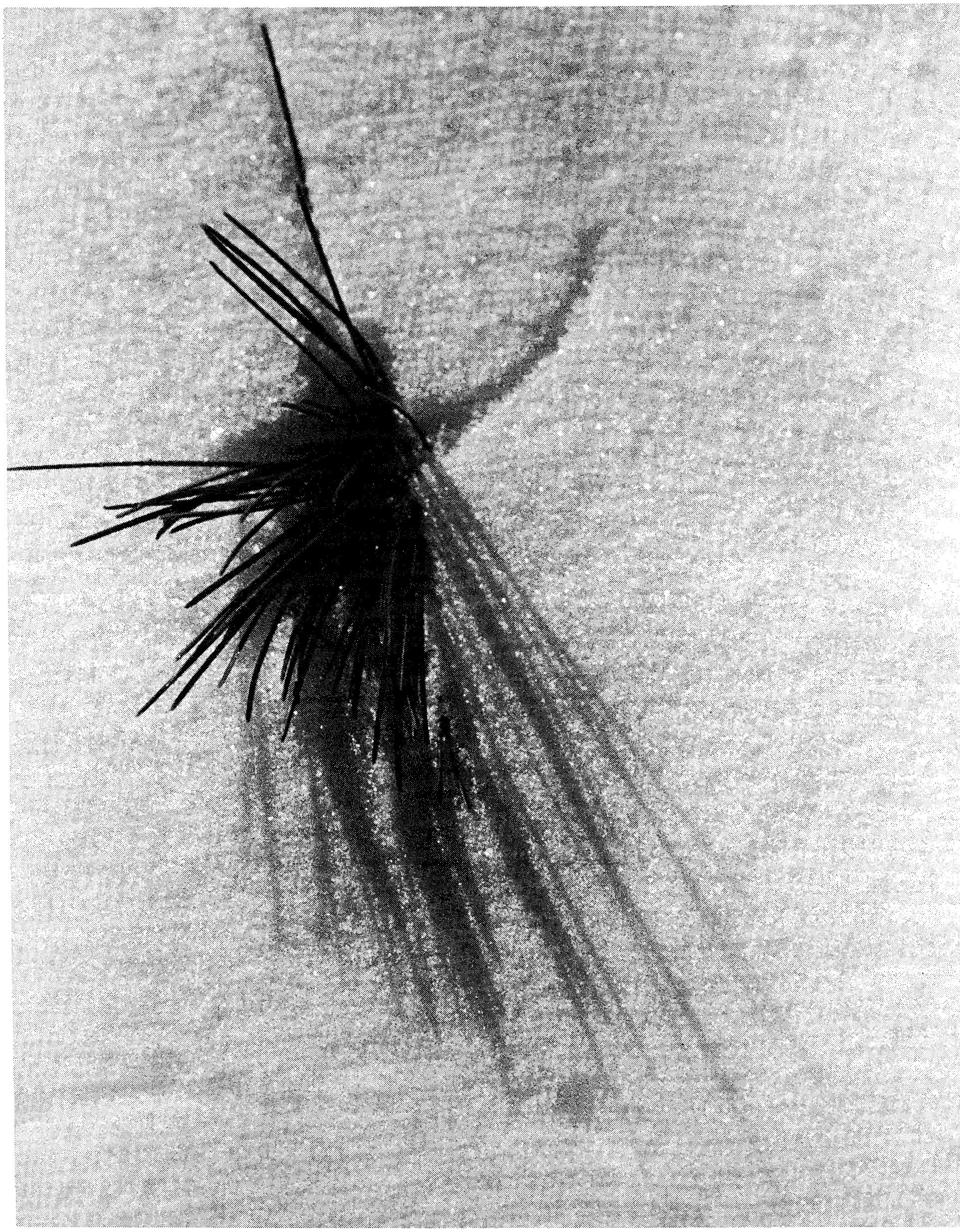
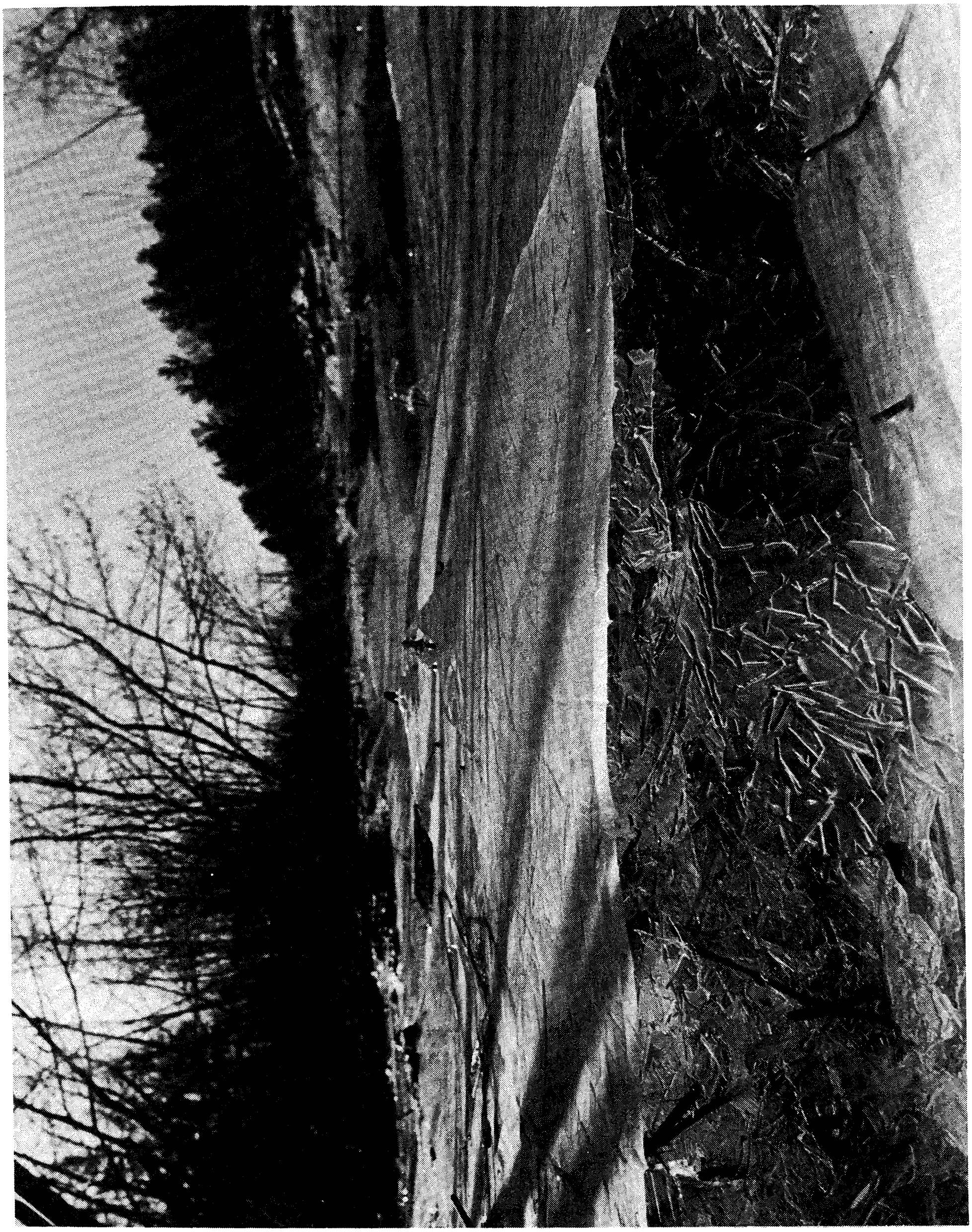
The Photography of David Ford Hansen

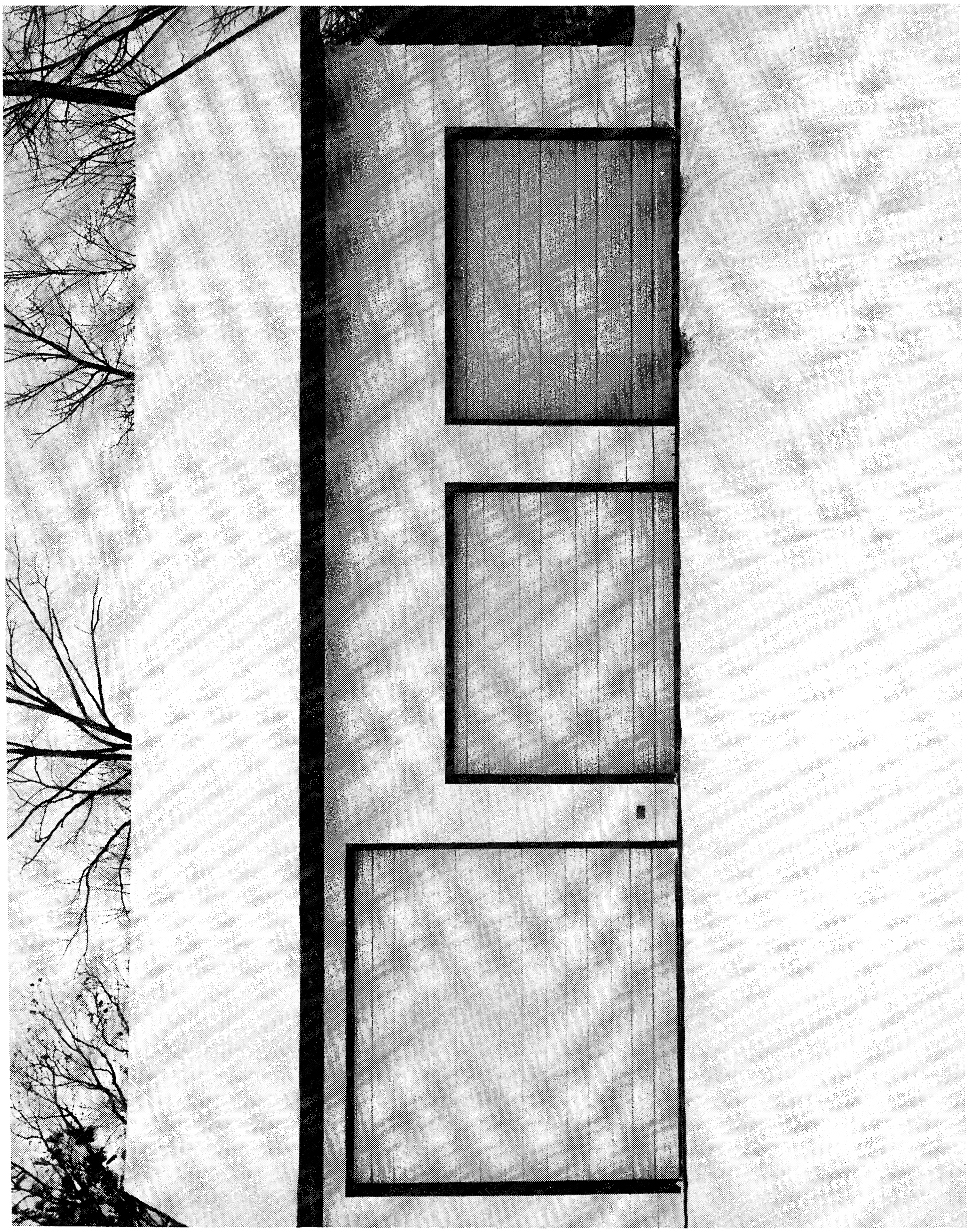
Those readers familiar with State photograph attributions have seen the name David Ford Hansen in virtually every major State newspaper and magazine. His photographs have illustrated three books about the Mississippi as well as a recent book on the Chippewa Valley. David is known not only for his technical skill but for his ability to capture universal human emotions. This collection of photographs, taken between 1973 and 1988, illustrates these two points. The technical skill demonstrated in the winter scenes allows the viewer to concentrate not only on the images but also on the contrasts, the starkness, and the incredible detail. In the three photographs of people, one encounters the joy and wonder of the young, the complexity of a boy on a bicycle, and the enigma of a young girl as she views herself in a mirror.

David Hansen teaches photography and writing courses as Assistant Professor of Journalism at the University of Wisconsin-Eau Claire.









Aging Effects and Older Adult Learners: Implications of an Instructional Program in Music

David E. Myers

A persistent concern in educators' attempts to meet the needs of an expanding adult clientele has been the relationship between learning and the aging process (Cross 1981; National Center for Education Statistics 1983; Gamson 1984). Despite longstanding evidence of diminishing cognitive, perceptual, and motor skills associated with increasing age (Chapanis 1950; König 1957; Lebo and Redell 1972; Salthouse 1979, 1982; Botwinick 1984), the practical effects of such declines in learning performance have not been clearly established. Some researchers suggest, for example, that the normal and expected effects of aging may have only limited negative effect on the tasks of everyday life (Schaie and Parr 1981). As learners, older adults may overcome potentially adverse effects of age-related deficits by drawing on their considerable life experience, by using a broad range of compensatory strategies, and by selectively attending to matters of particular meaning or relevance (Schaie and Parr 1981; Perlmutter 1983; Labouvie-Vief 1985).

Historically, assumptions of less efficient learning among older adults have paralleled other more general negative attitudes and beliefs regarding aging (Botwinick 1984). Research based on laboratory tests has tended to support the view that older adults do not learn as fast or as much as younger adults. However, such research sometimes has been based on content and procedures having little familiarity or meaning for older adults (Demming and Pressey 1957).

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Age-related declines in sensory processing and behavior time raise particular questions regarding older adult learners in a subject such as music, which incorporates sensorimotor skill development. Combinations of activities involving simultaneous listening, moving, singing, and playing instruments are considered central to music learning (Mark 1986); Gordon (1980) and Mursell (1958) have suggested that the inherent processes of music learning do not change with age. Gibbons (1982) found that elderly subjects desired music education programs because they wanted to improve their music skills. However, Gilbert and Beal (1982) found in a survey that adults over fifty-five expressed reluctance to participate in physically active, skills-based music learning.

Gardner (Brandt 1987–1988) has contended that assessment in the arts is fruitless unless people have had opportunities to become actively involved in artistic experiences. Thus, it is possible that older adults who have not participated in physically active music learning (or have not done so for an extended period of time) may express reluctance to participate in skills-based programs. Cross (1981) has suggested that development of education programs for older adults should not be based on conclusions from research confounded by situational variables but on investigations into the physical, psychological, and sociocultural characteristics of older learners.

To date, almost no research has addressed questions of adult music learning in the context of characteristics observed in an implemented skills-based instructional program. In this study, the relationship between age and music learning was assessed within an implemented skills-based music fundamentals program founded on a widely tested model of instruction (Froseth 1983). The criteria providing a framework for the study were as follows: (1) an instructional program that provided sequential acquisition of skills and knowledge deemed integral to understanding in music; (2) accessibility and flexibility in adapting techniques and materials to the needs and interests of participants; and (3) a performance-based assessment model that incorporated fundamental musical response as a basis for comparing aspects of music learning among adults of various ages. These criteria helped to ensure both the validity of instructional practice and the focus of the research on the music learning process.

Purpose

The primary purpose of this study was to investigate the relationship between age and music-learning achievement among three age groups of adults. Ancillary purposes included age-group comparisons of learning rate and of self-perceived attainment. Implementation of an instructional model that merged sequential development of music skills and understanding with the needs and interests of participating adults was considered central to these purposes.

Research subjects were volunteers who responded to a call for subjects and a description of the program offered through newspaper advertisements, visits by the researcher to community and senior centers, and posters. They represented three age levels: 22–37, 50–59, and 60–76 years. Though nineteen others participated, analyses were limited to thirty-two subjects who attended at least sixteen of twenty offered hours of heterogeneous group instruction and completed a testing program. Of these, eight were in the youngest age group, six were in the middle group, and eighteen were in the oldest group. All participants considered themselves unskilled in fundamental music learning, and all were individuals who maintained active, independent life styles.

The instruction focused on the development of aural-discrimination learning as a foundation for musical understanding. Four primary response modes were employed: (1) kinesthetic response through movement to beat (steady pulse), tempo (faster and slower pulse), and meter (beat groupings); (2) singing, including aural imitation of melodic patterns sung and played by the instructor, association of melodic syllables with the patterns, and vocal performance from melodic notation; (3) instrumental performance, incorporating imitation of melodic patterns played by the instructor and heard on a tape, and performance of patterns from notation using a soprano recorder; and (4) vocal rhythmic response, incorporating aural imitation of patterns performed by the instructor, association of rhythmic syllables with patterns, and performance of rhythmic patterns from notation. Autoharp and guitar performance tasks were included but not tested. Instruction moved in sequence from imitative experiences in moving, listening, and singing through aural-verbal association skills (melodic and rhythmic syllables) and visual-verbal association skills (notation) to music reading and performance. Instructional technique consisted of presentations of material synchronized with tape-recorded musical backgrounds, modeling-imitation sequences, and opportunities for review, practice, and elaboration of presented materials.

Method

The study was designed as a cross-sectional assessment of learning achievement, learning rate, and self-perceived attainment. Performance behaviors taught in the program provided the basis for assessment of achievement. Five pretests were administered to obtain baseline data on levels of musical skills: musical discrimination, kinesthetic response to music, melodic imitation skills, and melodic and rhythmic reading-performing skills. Posttests included the same instruments for musical discrimination and kinesthetic response. Six additional posttests were devised to assess facets of achievement specific to the instructional program: melodic imitation and syllable association (singing); melodic imitation-playing skills (soprano recorder); melodic reading-singing skills; melodic reading-playing skills; verbal rhythmic imitation and syllable association; and rhythmic reading skills (verbal). Tasks included answering multiple-choice questions (musical discrimination), tapping a woodblock (kinesthetic response), singing (melodic and rhythmic), and playing recorder (melodic tasks).

Learning-rate observations were recorded on a three-point scale (1 = slowest, 3 = fastest) during portions of instructional sequences that used a tape-recorded musical accompaniment to maintain consistent music tempos and rates of content presentation for all learners. Two trained unobtrusive observers recorded data during seven class sessions in five categories of activities reflecting the instructional sequence used for each class. These categories were: kinesthetic response, rhythmic imitation and association skills (listening and chanting syllables), melodic imitation and association skills (listening and singing syllables), melodic ear-to-hand skills (listening and playing), and reading-performing skills.

Self-perceived attainment was assessed by means of a questionnaire. Subjects used a five-point scale to indicate self-perceptions of their enjoyment, the personal value of learning tasks, their success on learning tasks, their progress over the course, and their overall levels of participation. In each category, responses were requested for specific learning activities emphasized in the instructional program: movement, melodic syllables, rhythmic syllables, music reading, recorder playing, autoharp/guitar experience, and applications in performance.

Age-group comparisons of the data were made on the basis of appropriate parametric and nonparametric measures, including t tests, analyses of variance and covariance, the Mann-Whitney U test, the Kruskal-Wallis analysis of variance by ranks, correlations, and the chi-square test. Because the sample was small and nonrandomized, nonparametric analyses were compared with parametric analyses for all data. Results consistently were similar. Because of the widely documented lessening of aural acuity associated with age, all subjects received a hearing screening administered by a certified audiologist.

Pearson product-moment correlations for inter-rater evaluations for three judges on achievement tests ranged from .97 to .99. Inter-rater reliabilities for two judges on unobtrusive observation of learning rate ranged from .81 to .99.

Findings

Instructional Efficacy

Statistically significant achievement ($p < .05$) in musical discrimination and kinesthetic response, assessed by paired t pretest–posttest comparisons, was attained in all age groups (Table 1). Posttest means on remaining measures indicated achievement among all age groups (Table 2).

Table 1. *Pretest-Posttest Mean Comparisons for Musical Discrimination and Kinesthetic Response*

Musical Discrimination						
Group	Pretest	Posttest	Diff.	S.D.	t	p
Youngest (N = 8)	30.25	35.13	4.88	5.82	2.37	.049
Middle (N = 6)	27.50	37.17	9.67	3.67	6.45	.001
Oldest (N = 18)	28.50	34.00	5.50	2.92	8.00	.000
All Groups (N = 32)	28.75	34.88	6.13	4.19	8.27	.000
Kinesthetic Response						
Group	Pretest	Posttest	Diff.	S.D.	t	p
Youngest	38.29	43.58	5.29	2.95	5.07	.001
Middle	31.44	37.67	6.22	4.04	3.77	.013
Oldest	29.67	37.39	7.72	3.73	8.78	.000
All Groups	32.16	38.99	6.83	3.66	10.57	.000

Achievement

No evidence was found to suggest declining achievement associated with increasing age. Statistically significant age-group achievement differences ($p < .05$) were found only on the assessment of melodic reading-singing skills. On this measure, the oldest age group was favored over the youngest age group. Both t test comparisons and the one-way analysis of covariance, adjusting for previous music learning experience and pretest achievement, supported this result (Table 3).

On pre-instructional levels of kinesthetic response, the oldest age group was significantly inferior ($p < .05$) to the youngest age group. On the posttest assessment of kinesthetic response, however, there were no significant age-group differences (Table 4). Thus, a pre-instructional kinesthetic disadvantage among the oldest learners was apparently diminished over the course of instruction. This finding is notable in light of physical limitations often experienced by older adults and in view of research findings suggesting a reluctance among older adults to participate in physically active, skills-based music learning (Gilbert and Beal 1982).

Aural acuity did not appear to be a factor in pretest, posttest, and change-score measures. Hearing patterns followed the documented trend of high frequency losses associated with increasing age (König 1957). Three subjects in the oldest group failed the hearing screening. However, all of these individuals realized achievement in the program. Inclusions and exclusion of failing subjects' achievement data did not alter age-group comparative analyses. A review of raw data, however, did indicate tendencies of failing subjects to score in the lower two quartiles on achievement measures. A notable ex-

Table 2. *Maximum Attainable Posttest Scores, Extreme Scores, Means, and Standard Deviations By Age Group*

Melodic Imitation/Syllable Association (Singing)				
Group	Maximum	Extremes	Mean	S.D.
Youngest (N = 8)	80	18-78	56.63	22.72
Middle (N = 6)	80	26-78	57.00	22.16
Oldest (N = 18)	80	11-79	62.73	17.44
Melodic Imitation (Playing)				
Group	Maximum	Extremes	Mean	S.D.
Youngest	54	25-52	36.58	8.44
Middle	54	11-47	31.67	12.04
Oldest	54	16-53	37.67	9.08
Melodic Reading (Singing)				
Group	Maximum	Extremes	Mean	S.D.
Youngest	56	0-48	20.13	17.63
Middle	56	0-50	25.11	17.59
Oldest	56	0-54	36.78	18.37
Melodic Imitation (Playing)				
Group	Maximum	Extremes	Mean	S.D.
Youngest	40	20-39	29.25	7.49
Middle	40	13-36	24.61	9.50
Oldest	40	20-39	30.04	5.83
Rhythmic Imitation/Syllable Association (Verbal)				
Group	Maximum	Extremes	Mean	S.D.
Youngest	49	36-48	42.71	3.65
Middle	49	33-46	41.89	4.62
Oldest	49	31-46	41.33	4.63
Rhythmic Reading (Verbal)				
Group	Maximum	Extremes	Mean	S.D.
Youngest	56	42-56	49.67	5.01
Middle	56	32-56	46.10	7.78
Oldest	56	24-55	46.87	7.25

ception to this trend was one failing subject's placement in the highest quartile on musical discrimination change scores.

Learning Rate

Learning rate, defined as immediacy of success on specific performance tasks, appeared to be slower for middle and oldest subjects than for youngest subjects in all five of the assessed categories (Table 5). Unpredictable attendance patterns, however, made consistent data collection and planned analyses impossible. Though an apparently slower learning rate did not seem to have an impact on achievement, there was some anecdotal evidence to suggest that learners in the oldest group were more inclined to practice between sessions than were their younger counterparts. Slower rates may thus have been compensated in the oldest group by increased effort and rehearsal.

Self-Perceived Attainment

Analyses using the Mann-Whitney U test and the Kruskal-Wallis one-way analysis of variance by ranks indicated that self-perceived attainment scores were stronger for oldest than for youngest learners in five categories: overall participation; overall attainment in melodic syllables tasks; participation in melodic syllables tasks; enjoyment of melodic syllables tasks; and enjoyment of music reading tasks ($p<.05$). On recorder-playing tasks, however, oldest learners' self-perceptions of their success were significantly lower ($p<.05$) than those of youngest learners (Table 6).

Qualitative Observations

Qualitative observations recorded by the researcher following each instructional session and during individual testing supported quantitative findings. Oldest subjects responded more favorably than youngest subjects to melodic singing tasks. Though youngest subjects appeared to demonstrate greater rhythmic responsiveness than those in the middle and oldest groups, no quantitative results supported this observation. A distinctive trait of the oldest group was the stability of attendance patterns in contrast to less consistent attendance patterns of the youngest group. At eighty years, the oldest participant did not complete the testing program but did improve markedly in his ability to discriminate pitch and perform accurately in singing and playing recorder. He reported that he believed the results of his participation would have been no different at age thirty from those realized at age eighty.

Discussion and Implications

Evidence obtained in this study suggests that increasing age may not be a disadvantage for older adult participants in performance-based music learning programs. Not only was there an absence of diminished achievement among older adults, but those subjects in the oldest age group scored significantly higher on melodic reading-singing tasks than those in the youngest age group.

In relation to the superior performance of older adults on the melodic reading-singing assessment, it must be noted that adults in the oldest group clearly were more comfortable than those in the youngest group with learning tasks that involved singing. It is possible that generational differences contributed to this result. Older adults were perhaps more likely to have experienced family and social group singing during their youth. In addition, the popular musical idioms of their young adult years were no doubt strongly melodic, perhaps establishing lifelong predispositions toward melodic sensitivity and singing tasks.

Another facet of older adults' singing inclinations may have been that singing was once a primary element not only of music education programs but of school

Table 3. *Age-Group Comparisons of Melodic Reading-Singing Skills*

Assessment				
Group	Mean	S.D.	t	p
Youngest (N = 8)	20.13	17.63		
Oldest (N = 18)	36.78	18.37	−2.16	.04

One-way Analysis of Covariance Table

Source	df	ss	ms	F	p
Equal Adj. Means	1	1508.00	1508.00	6.30	.02

Table 4. *Kinesthetic Response Comparisons for Youngest and Oldest Age Groups*

Variable/Group	*Mean*	*S.D.*	*t*	*p*
Pretest				
Youngest (N = 8)	38.30	9.13		
Oldest (N = 18)	29.67	6.73	2.70	.01
Posttest				
Youngest (N = 8)	43.58	8.39		
Oldest (N = 18)	37.39	8.22	1.76	.09

Table 5. *Mean Age-Group Learning Rates Over Seven Assessments*

Variable	*Youngest (N = 8)*	*Middle (N = 6)*	*Oldest (N = 18)*
Kinesthetic Response	2.92	2.53	2.46
Rhythmic Imit./Assoc.	2.86	2.68	2.74
Mel. Imit./Assoc.	2.83	2.50	2.72
Mel. Ear-to-Hand (Rcdr.)	2.78	2.45	2.64
Reading/Perf.*	2.83	2.64	2.66

* Only six assessments were made in the Reading/Performance category.
(3 = fastest rate)

Table 6. *Comparisons of Oldest and Youngest Groups on Self-Perceived Attainment*

Category	*Average Rank Youngest (N = 8)*	*Average Rank Oldest (N = 18)*	*U*	*p*
Overall Participation	8.94	15.53	35.50	<.05
Overall Mel. Syllables Attn'mnt.	8.37	15.81	30.50	<.00
Participt'n. Mel. Syll.	5.43	17.08	7.50	<.00
Enjoyment of Mel. Syll.	8.06	15.92	28.50	<.01
Enjoyment of Mus. Reading	9.06	15.47	36.00	<.05
Success in Playing Rcdr.	18.50	11.28	32.00	<.05

experience in general. Singing tasks, therefore, especially when combined with the reading skills that make melodies more accessible, may have been strongly congruent with older adults' existing connotations of music learning. Motivation for melodic singing tasks thus may have been stronger in the oldest age group. In addition, if melodic tasks had greater meaning, they were probably valued more highly than nonmelodic tasks.

Although in this study learning rate appeared to lessen with age, achievement was not affected. Oldest learners, however, were consistently more likely than middle and youngest learners to take advantage of elaboration offered immediately following controlled presentation segments. It is possible, therefore, that lack of diminished achievement among oldest subjects may have been related to these subjects' willingness to request repetition and/or explanation of material.

Stronger self-perceptions in the oldest group for participation and enjoyment in melodic syllables activities and for enjoyment of music-reading activities are consistent with achievement results favoring the oldest age group on melodic reading-singing tasks. Similarly, strong self-perceptions of overall participation among the oldest group parallel reports of high motivation levels among older adults documented in nonmusic studies (Kastenbaum 1979).

The less favorable self-perceptions of success among older learners on recorder-playing tasks, however, were not reflected on melodic imitation (playing) and reading-playing achievement measures. This result suggests the possibility of a dichotomy between real and self-perceived capabilities. Older learners may be subject to their own stereotypical notions of decreased capability, especially where psychomotor skills are involved. Particularly if they have experienced certain of the physical declines associated with aging, older learners may tend to feel less successful than younger learners on multisensory manipulative tasks. The importance of sequential, success-oriented instruction that enhances self-perceptions would thus seem to be paramount for older adults.

Music educators have long held that learning opportunities should be available to people of all ages. Further investigation of the trends suggested in this study, along with increased information regarding the developmental needs and interests of adults, will help ensure design of appropriate music education programs for adult learners.

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From Wisconsin Poets

Much of the poetry in this issue has been informed by the area in which the poets live and work. Most apparently this is demonstrated in the sense of living history, whether recent or remote, in poems such as "The Mission of Birds" by Frank Smoot, which draws its title and inspiration from the 1898 Black River Falls high school yearbook, and in "Trees," a dark and terrifying sestina by Sara Rath, which was occasioned by an excerpt from the *Wisconsin State Journal* in 1987.

Broader influences and concerns are evidenced in the stark landscapes of John Judson and Denise Panek—the former, one of the most consistent and recognized, the latter one of the newer and most promising poets living in Wisconsin. Even the savage irony involved in land-locking the oceanic passions of Tristan and Iseult, or Aphrodite and Neptune, into a prairie cornfield as does Gianfranco Pagnucci in "La Mer La Mer," or the microscopic attention to naturalist detail of Travis Stephens' poems can best—though not, of course, exclusively—be appreciated within a Midwestern context.

Finally, the indictments—delicate or immense—of first "Christy," then "The Children of Nicaragua" by J. D. Whitney, or the absolute poetic mastery displayed in Dick Terrill's "The Azaleas" or "Azaleas"—which begins with the problems of love, particularly lost love—transcend any geographical concerns, and speak to the scope and variety of subjects and attitudes displayed by Wisconsin poets today.

The Mission of Birds

Black River Falls, Wisconsin, 1898

This girl, dead or past a hundred,
who under a tall jack pine
lay all afternoon and wrote a speech
about *The Mission of Birds,*
is lying in a photo album
wearing her best print dress,
just failing to look stern enough.

It's the same dress she lifted as she climbed
the stairs of the platform in the gym
to give that speech—keeping the promise
of the motto of her class,
"We'll find a way or make one."
She married a Falls boy three years older
who also finished school,
raising a hand to his class motto,
"Work is the law of life."

*

At that abandoned house they'd built
fall is a tragic afternoon,
each dusk more slender
than the last, the light gone early
toward winter solstice—their fumbling desire.
A hawk hunts the wreckage of an elm
for mice, against all hope.

Frank Smoot

Frank Smoot is currently finishing a graduate degree in poetry in Vermont. He has edited an anthology of poetry and fiction and served as editor of several Wisconsin poetry magazines. When not in Vermont, he and his wife Susan Enstrom (a musician and artist) live in Milwaukee.

Making History

for my mother

"Watch the hands," she says, "if he moves
his hands like this, she also moves like that.
The skates, arms, eyes are parallel like one dancer."

My mother has seen one son attempt suicide.
She has started new, at fifty, judging goats—
she made all the national journals this year.

And now she's watching Torville and Dean,
the British ice dance team, skating to *Bolero.*
It makes history, their perfection.

She's businesslike about the goats
and loves them and her tears at this
are like the stars caught in the ice.

Meanwhile my father, a gentle atheist
who has seen a son join the Catholic Church,
is in his shop, tinkering and drinking wine.

One time he spent the whole day
shaping hickory into a one-inch cube—
it's an impossible exercise in fine carpentry.

They spend their summer days
with the gate from shop to barn between them,
his hands like this, hers like this.

Frank Smoot

American Tale

The herring gulls increased over landfill
where Interstate signs directed tomorrow.

Lined with taxis, the streets dreamed of ending,
spoke in accents, dressed Italian,
denyed the black at their militant heart.

Then Saturdays came—cigars over bitter coffee,
newsprint news that came off on my hands.

Sundays were park swans, longing for children.
And when I told what I saw, they said:

The algorithm's not quite in your favor.
You must know computers, follow your broker
as the beggar does his one white cane—

This century won't be caught dead in poems.
Its epic is color, smaller camcorders,
Koreans out-researching the Japanese.

But in March, at light, I remembered a stream
seining through pastures, granite tucked
along shoulders where green

repeated its reasons.
And I forgot the width of pavements,
and walked, again, toward what first scented the air.

John Judson

John Judson teaches at the University of Wisconsin-LaCrosse and is editor for Juniper Press. His most recent book, North of Athens, *was published by Spoon River Poetry Press. His current poems are found in such diverse places as the* Kansas Quarterly, The Laurel Review, *and* Poetry.

Rivercliff: 1939

No children of divorce, no separation
enforced by law in our homes, all
distance had to be earned, all
privacy burned at alters mothers served,
gossiping by phone how good we were,
and thereby advertising affiliation.

So we took to the woods in gangs,
Robin Hooding the north shore of The Sound
a society structured and planned
by how close you lived to water:
some had houses moored
to docks that rose and fell
on what Wall Street walked upon;
others chained to dingys and yachts,
summer passage by wind
to darker sand, or islands
abandoned as Maine.

Until the War, when
older brothers and fathers left
and only some came back,
and the Coast Guard called upon us
for the duration
to drown light each night,
and those not working for Defense
went without four years of gas
or vacation.

John Judson

Snapshot 1: Ashland, Wisconsin, February 11, 1987

The great Lake Superior is white and black
open patches of darkness, a watery landscape
yesterday, 46, today the winds
leave blisters of ice
on the cars parked,
with their engines bleating at the cold—
from the car, people like us
read the historical markers
about Moningwanekoning and about
the Jesuits and the about the people
they called the Chippeways.

Snapshot 2: The German sisters, February 14, 1947, Black and White

Wearing white butcher's aprons
and hose that ended at the knee
black to match shoes and hairnets
over hair pulled back so tightly
the corners of their eyes tilted up
on sundays, the sisters watch televised mass
on the Zenith, the picture of Pope
Pius hung above the television console,
votive candles on ivory doilies—their houses
dark except for the dim artificial lights
of the manger scene complete with Star of Bethlehem
The setting took up half their living room area
until Mother's Day.

Snapshot 3: Farm Auction, Olney, Illinois, "The White Squirrel Capitol of the World," April 20, 1986

Tilted seed caps block the afternoon sun
while eyes follow the red and black chainsaw
Homelite, black and heavy, it goes for 25.
The Mennonite woman wears her bonnet
in an unusually reckless fashion
but it is too warm to keep
a bow tighted neatly beneath the chin—
somewhere a clang of horseshoes and old garden tools
are brought out into the open
like quarrelling roosters before a crowd of gamblers
they are examined quickly and then the
auctioneer raises the dusty crate
high above the crowd, asking
who will give him a dollar bill.

Denise Panek

Denise Panek lives in Eau Claire where she is Manager of Conferences and Institutes for the School of Arts and Sciences Outreach Program. She is a White Earth Ojibwe whose poetry and fiction have appeared in such journals as: Calyx, Sinister Wisdom, *and* Plainswoman.

La Mer, La Mer

Two porpoises along a sea coast would laugh
at you, white Aphrodite up from pastures of holsteins
and me Neptune of prairie corn, blackbirds in my hair,

laugh at how each summer we meet in the bed of the lake,
our feet planted in sand
and embrace seas of earthy emotions we hardly understand.

Sometimes we gulp water, and a land breeze laughs through the trees.

When a herring gull drops out of the air,
surveys the lake close up, east then west,
and goes off after the taste of salt in his nostrils,
we look up, remember a small hill of sand
and climb down toward our pond, laughing to ourselves.

Soon we shiver away from each other;
the gull's raucous cries come back from nowhere.

This far inland it's hard to imagine the sea.

Gianfranco Pagnucci

Gianfranco Pagnucci is a member of the English faculty of the University of Wisconsin-Platteville. His poetry has appeared in numerous periodicals and anthologies, and he has published three books of stories and poems with fourth and fifth books due to be published in the fall and winter, 1988.

Wildflowers for Dorothy

That was the summer I waited for darkness,
and told myself I didn't have time.
I pretended to ignore my friend,
who lived alone with her widowed father
and sold subscriptions to magazines.
She seemed as quaint and old fashioned
as a childhood fantasy I'd outgrown.

Each May Day I'd searched
for the earliest hepaticas,
wood-sorrel, buttercups, trillium,
yellow violets; wrapping a quaint
nosegay in a paper doily laced
with ribbon. I'd place it in Dorothy's lap
by her hand that lay like a dead white bird
on the shawl that concealed
her withered legs.

That summer I slipped books of Gothic romance
out of the village library and hid
in my bedroom to dream until twilight.
Later, Dick and I lay in the long wet grass
of the park behind the bandstand, pushing
adolescent bodies against each other
until our cheeks were chapped
and we were exhausted, breathless, from
silent passion in the streetlights' shadows.

The papery-thin whiteness of the dead
bird hand Dorothy waved in my dreams
was a haunting farewell.
That summer wood-sorrel and rue anemonoe
wilted in a jelly jar next to my bed.
I pressed violets between pages
of Teasdale's poems, plucked petals
from bloodroots and recited the frightening
litany he loves me, he loves me
not, he loves me . . .

Sara Rath

Trees

There are hiding places here no one has seen
but me. I crouch in shadows dark with night
beneath a sky of leaves along the edge
of pastureland nearby; these trees
and that oak grove the cardinal whistles from
remind me of my childhood and Grandpa's woods.

There'd been a slaughter house down in that woods
of childhood, where we played out gory scenes
with cowskulls in the grass, bleached remnants from
past decades, never going there at night,
too frightened by pale ghosts among the trees
or moss-crumbling walls at river's edge.

When I was twenty-nine I toed the edge
of danger and abandon in dense woods
much like these, dancing nude among the trees,
posed while a camera caught that jubilant scene.
I felt a reckless sense of joy that night,
a secret courage. I'd escaped from

rigid roles: wife and mother; from
identities that pressed me toward the edge
of thirty. But, ironically one night
much later—fifteen years perhaps, I would
suppress the memory of that pose, that scene.
A friend in prison wrote, "Watch out for trees!"

I asked him what that meant, and he said, *trees*
was prison slang for rapists. Coming from
a source like that, I now look at this scene
of mossy oaks and rocks with nervous edge.
They've found abducted women in our woods,
nude, chained to trees, shot dead. One more last night.

This summer women lock their doors at night
and walk outside with caution. Even trees
are threatening; I'll escape this woods
and others but there is no hiding from
the darkness that begins along this edge
foreshadowing the nightmares we will see.

As investigators combed the scene for clues last night
deer appeared at the edge of the trees
and wild turkeys called from the walnut and oak woods
in the valley . . .

excerpt from *Wisconsin State Journal*
Madison, WI August 6, 1987

Sara Rath

Sara Rath has been a freelance writer for over twenty years. Her third book of poems, Remembering the Wilderness, *received the Wisconsin Library Association's Banta Award while her most recent book* About Cows *won the Council for Wisconsin Writers award for best nonfiction book of 1987.*

Morchella esculenta

This musette is bulging with dinner
fit for the taking. Morels.
Along this dusty road they hide
in damp-sandy pockets where
the sun is slow to arrive.
"Good thing we beat the road grader,"
I say as you dash to the next cluster,
"if only all summer were as easy as this."

Later, at the pump,
you slowly pumping,
I wash sand from the waxy heads.
What a delicate fist is the mushroom,
locking so much in wafer ribs.

Like fish from the river,
berries from the woods,
a respite of luck
there for the taking.

Travis Stephens

Travis Stevens is a 1985 graduate of the University of Wisconsin-Eau Claire and most frequently writes of the northern Wisconsin dairy and pulpwood region. These poems, however, come directly from experiences of the past several years spent working in Glacier Bay, Alaska.

The Tiniest Crab

Walking the beachline out
beyond where tidal flats stretch,
where tide has just receded
we sift the sand
for becalmed offerings.
A crab is found,
shell intact but empty,
wide across as two fingers
side by side.

In that lacy fringe of seaweed scrap
at surf's farthest fingertip reach
we find more.
A Dungeness, a Tanner, both
empty and small, hollow,
and light as a flower.
And later,
the tiniest crab,
smaller than a fingertip
all legs intact, light as breath.
He comes with us wrapped
in a tissue, tucked into a pocket.
Tossed much farther than
the great ocean intended.

Travis Stephens

"The Azaleas" or "Azaleas"

"When you go," "If you go" begin two translations
of the great poem by Kim Sowol,
whose azaleas, which burn in version A,
are gathered twice on a green mountainside, or perhaps a hill.

Are the famous flowers in armfuls or in another measure,
    unspecified?
Is she through with him, or just sick and tired
is what choice we're left as the poet,
that lover who bids good-bye quietly
or without a word,
is left, we conclude, with emptiness.

Some evenings in her dim office we translated
the minor poets—Mi Kyung with dictionary,
her desk light a yellow island,
me with pacing coffee about to make
art out of the least utterance, out of
the brown creaking of her dusty chair.
Mostly her voice became soft
when she began to read
her finished drafts—title first,
inflection dropping in lyric pain—a cultural obsession—
followed by a dark pause for stillness:
"Spring Night"   "Paper Kite"
"To the Wind"   "Musky Scent"
"Rainy Day". . . . She was afraid, she said,
it would not sound the same or right in English

but it's all I can know, the translations, and so today
I will not weep or show tears,
perish or die, but want
to scatter, strew azaleas in her path
before her light, soft, gentle, gentle step.

Richard Terrill

Richard Terrill has received the Wisconsin Arts Board Literary Arts Fellowship and is currently a Regents Fellow in American Culture at the University of Michigan. He has been a Fulbright Professor of English in Korea and a Visiting Professor of English in the People's Republic of China.

The Children of Nicaragua

will disappoint us.
                                        Their faces
bright.
            The
depths of their eyes.
You could almost think
                                              if
less off-white
they were American.
They even smile.
If they are moving
                                    toward
a future
              it
is the wrong one.
They will disappoint us.
We want them
                            strong
& tireless
                moving
relentlessly north
                                great
bunches of fruit on their
backs for us.
Bananas.
                Their
soft meat
                delicate
& sliced
to grace our breakfast.

J. D. Whitney

J. D. Whitney lives and works in Wausau, Wisconsin. He is professor of English at the University of Wisconsin-Marathon Center and has published a number of collections of poetry including Hello, Tracks, The Nabisco Warehouse, Some, Tongues, Mother, *and most recently,* Word of Mouth *(Juniper Press, 1986) and* sd *(Spoon River Poetry Press, 1988).*

"Christy"

on
her back-
pack
blonde
7
maybe
8
a
hook where
one hand was
she
rides the bus.
She is
lovely
small &
clear light's
in her eyes.
She
&
friend
whisper
some out-
rageous thing
about
the
driver's
hairy ears.
He
is crabby
every
day
deserves it.
Warm
days
she
wears no
mittens
cold
days
one.

J. D. Whitney

Holocene Lake Fluctuations in Pine Lake, Wisconsin

Rodney A. Gont, Lan-ying Lin, and Lloyd E. Ohl

Abstract. *Middle and late Holocene water level fluctuations were inferred from a comparison of fossil diatom communities found in the sediments of the main basin and a bay of Pine Lake, Wisconsin. From 7500 to around 4500 years* BP *the water table was low enough to have kept the bay separated from the main basin. By 3765* BP, *the barrier had been overcome and the lake surface was near its present elevation. Based on an approximate 300 year subsampling interval, the water level has risen and fallen three times on a 1300 year cycle since 3765* BP *but has varied less than one meter in elevation.*

The surface level of a lake can be affected by a number of environmental factors. The effects of periodic drought, clearing of wooded watersheds by fires or logging, and blocking of drainage by dams last as long as half a century, but they usually persist far less than this (Charles and Norton 1986; Borman et al. 1974; Birch et al. 1980). More lasting are the changes wrought by climate, which often reach regional and even continental scale (Wright 1969, Webb and Bryson 1972, Webb 1981, Winkler et al. 1986).

Pine Lake (Fig. 1), an oligotrophic, soft water, seepage lake on the Chippewa-Rusk county line in West-Central Wisconsin, has characteristics that dampen short-term lake level fluctuations. This was evident during a three-year (1979–1981) monthly benchmark study when the surface level of Pine Lake varied less than 35 cm. Located on noncalcareous till of a stagnant ice-core moraine (Cahow 1976), Pine Lake has a surface area of 106 hectares, maximum depth of 33 meters, a small drainage basin of only 197 hectares, and a shoreline development index of 2.56 (Sather and Threinen 1963). Soils of the drainage basin are almost exclusively Amery sandy-loam (Ald), class 4e, 12–25% slope (D. Goettl, USDA SCS Chippewa County office, personal communication). Recent land usage has kept the surrounding terrain mostly wooded (95% wooded in 1963) and only approximately 50 summer homes rim the shoreline. In 1976 Pine Lake was included in the Wisconsin Department of Natural Resources Benchmark Lake Program as an example of an undisturbed lake system.

Rodney A. Gont, RR 1, Jim Falls (Chippewa County), Wisconsin. Lin Lang-ying is Associate Professor of Biology at Jinan University, Guangzhou, People's Republic of China. Lloyd E. Ohl is a professor of Biology at the University of Wisconsin-Eau Claire.

Beauty Bay (Fig. 1), 2.4 hectares with a maximum depth of 15 meters, is located on the west side of Pine Lake. It is presently united to the main basin, but access is restricted by a submerged bar across the mouth of the bay. The apex of this bar, under approximately one meter of water, is comprised exclusively of boulders, apparently washed clean by wave action. The ground water flows from Beauty Bay toward the main basin (Tinker 1985).

A number of pertinent features are apparent on the USGS topographic map for the area (Chain Lake, WI N4515 W9122.5/7.5): 1) the immediate banks of both Beauty Bay and the main basin have a steep grade, 2) the system has an intermittent outlet, 3) there is a lack of agricultural development, and 4) no boggy or low areas are shown to directly abut either basin. A 1939 lake survey map

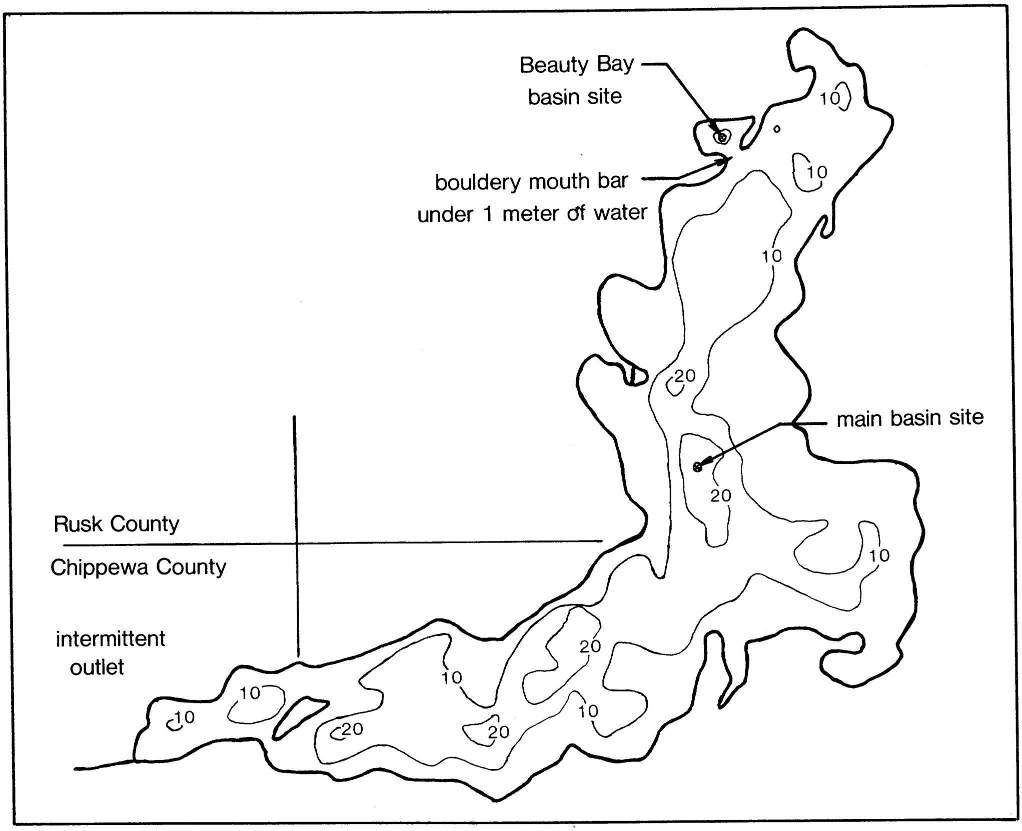

Fig. 1. Pine Lake, Wisconsin. Location of study sites in the main basin and in Beauty Bay.

of Pine Lake, compiled by the then Wisconsin Conservation Department using data from the WPA Lake Survey Project, indicates the immediate shoreline was completely comprised of upland woods of oak, oak-aspen, or pine. Recent cursory inspection of the surrounding woods confirmed the presence of sizable quantities of red oak *(Quercus borealis),* quaking aspen *(Populus tremuloides),* and white pine *(Pinus strobus)* directly at the lake front. In fact, one of the more noticeable features of both Beauty Bay and the main basin is the remarkable scarcity of aquatic macrophyte, lowland, and transition vegetation at the shoreline.

The oldest historic record of Pine Lake and its drainage basin is probably found in the original land survey conducted in the Pine Lake area in 1852. Features that would have been incidentally cited when encountered by the surveyor would have included Indian trails, roads, burned-over lands, and windthrows (Bourdo 1956). None of these nor any other human-related features were cited for the immediate vicinity of Pine Lake. The surveyor's description of Pine Lake at that time was "banks very high and steep, shores gravel and sand, water clear and deep, bottom sand, timber surrounding pond—Pine, maple, oak, and aspen." A present-day description would differ very little.

No direct evidence of historic human alteration of the bar separating Beauty Bay from the main basin was found. The 1972 Chain Lake, Wisconsin, 7.5-minute

USGS topographic map, both the 1948 and 1950 Weyerhauser, Wisconsin, 15-minute USGS topographic maps, and the 1939 Wisconsin Conservation Department Lake Survey Map all show Beauty Bay clearly united to the main basin. Alteration by pre-European natives might be conjectured, but there was no evidence for this and the bar appears to be a naturally deposited barrier, swept clean by wave action to leave boulders.

This study depended on the physical relationship of Beauty Bay to the main basin, the stability of the main basin, and the sedimentary record of fossil diatoms. The premise was quite simple. During periods of high water, when the mouth bar of Beauty Bay lay deeper beneath the surface, water would be more freely interchanged with the main basin. This would result in "contamination" of the littoral community of Beauty Bay with planktonic species adapted to the large, deep main basin. Conversely, when water levels were low, the bar would be covered by less water and could even be exposed. This restricted or blocked access to Beauty Bay would reduce, and possibly even eliminate, any similarity of the two diatom communities.

Procedure

In Beauty Bay a sediment core 320 cm long was removed using a Livingstone-style piston corer (Livingstone 1955). In the main basin the upper 115 cm were taken using a freeze-coring device (Swain 1973) while the sediment from 150 cm to 375 cm was extracted using the Livingstone corer.

During piston-coring, due to the depth of water over the study sites, a rigid pipe casing was assembled between the ice and the water-sediment interface. This casing, just slightly larger in diameter than the piston corer, was used as a guide to the proper location in the sediments and to prevent bending of the thrust rods during sampling. To increase penetration of the corer, two winches were attached, one end of each to the thrust rod of the corer and the other hooked under the ice. At maximum penetration, sufficient force was being applied to visibly flex the part of the thrust rod extending above the corer casing. Although the piston corer was forced into the sediments as far as possible, it would not penetrate a highly organic compact layer at 375 cm (7535 BP ± 135 yrs) in the main basin nor a similar layer at 310 cm (7565 BP ± 85 yrs) in Beauty Bay. This layer apparently is not a universal characteristic of Chippewa moraine lakes since the same corer was also used on nearby Oliver Lake #2 (Gont and Ohl 1985) to get sediments ^{14}C dated at over 11,000 years (unpublished data).

The piston cores were left in the sample tubes, frozen in the field, and taken to the laboratory where they were kept frozen during removal and subsampling. The freeze core was removed from the corer in the field, immediately wrapped in foil, and transported on dry ice to the laboratory, where it was kept frozen until subsampled.

Slices of sediment approximately 0.3 cm thick were cut from each core with a hacksaw at 10.0-cm intervals. This was later determined to approximate 300-year sampling intervals over the 4500-year time span when the two basins had prevalent species in common. These subsamples were oxidized using the hydrogen peroxide and potassium dichromate method (van der Werff 1953) and strewn-mounted (Patrick and Reimer 1966) on microscope slides using Hyrax (R.I. 1.65) as the mounting medium. In the main basin, random transects from a slide from each subsample were examined at 1250X with a Zeiss research microscope until a minimum of 500 (Stockner and Benson 1967, Weitzel 1979) diatom valves were identified and tabulated. Once the main basin prevalents were discovered, it was unnecessary to identify all frustules from the Beauty Bay subsamples, since only the "contaminants" from the main basin could affect the percent similarity index. A minimum of 500 diatom valves per slide were still inspected in the simplified count of each Beauty Bay subsample, but those species that had not appeared as prevalents in the main basin were tabulated as others. However, complete counts of 500 had been made at approximately 50-cm intervals along the Beauty Bay core in a preliminary study (unpublished data) and were available for reference. In all of the counts, the "dilution effect of dominants" (Kingston 1986) was not taken into account.

Dating was done by a ^{14}C method on 5-cm long core sections (minimum of 10g dry wt.) sent to the Radiation Laboratory of Washington State University (WSU sample numbers 3180–3187, 3189). Regional corrections for ^{14}C dates are available (Grootes 1983), but the dates in this paper have been presented as uncorrected.

Results

In the 34 subsamples examined from the Pine Lake main basin core, representing the last 7500 years, only three of the 212 diatom taxa identified were found in greater than 3% relative abundance in three or more levels. The distributions of these three, *Cyclotella stelligeroides* Hust., *Cyclotella comta* (Ehr.) Kutz., and *Tabellaria fenestrata* (Lyng.) Kutz. are shown in Figure 3. In the 32 subsamples examined from Beauty Bay, also representing the last 7500 years, the above prevalent species of the main basin suddenly appeared in relative abundance greater than 3% approximately 4500 years BP and remained as prevalent species in varying proportions to the present (Fig. 2).

Similarities of subsamples were determined by a $2w/(a+b)$ percent similarity index used by Bray and Curtis (1957), where w is the summation of the lowest count of each species in the two assemblages being compared, a is the total count from one assemblage, and b is the total count from the other. This index can range from 0 to 1—it equals 0 when the two assemblages to which it is applied have no species in common and 1 when all species are in common and the relative abundance of each species is identical as well. Because linear interpolation between ^{14}C dates was used to date many of the subsamples, correspondence between main basin and Beauty Bay basin subsamples could only be approximated. For this reason, a similarity index was calculated for two sets of data: 1) every Beauty Bay subsample and the nearest-aged main basin subsample and 2) every Beauty Bay subsample and the average of the two nearest-aged main basin subsamples. Both sets of indices were similar ($r^2 = 0.93$, $p < 0.01$) so only the data of set 1 were used in the analysis (Fig. 3). Subsamples with the greatest similarity to the main basin were labeled as high water levels and those with the least similarity as low water levels.

Discussion

An important consideration in any fossil study is how representative the sedimentary record is. This aspect was not directly tested in Pine Lake. However, diatoms have recently become the subject of numerous fossil studies investigating acid precipitation effects, and these studies have repeatedly reported that diatom remains in surficial sediments accurately represent the living community (Charles 1985, Haworth 1980).

The problems of sediment mixing and differential preservation of frustules have also been reviewed (Binford et al. 1983). By taking cores from the deepest part of the basin, the probability of mixing is greatly reduced (Kreis 1986). But even if

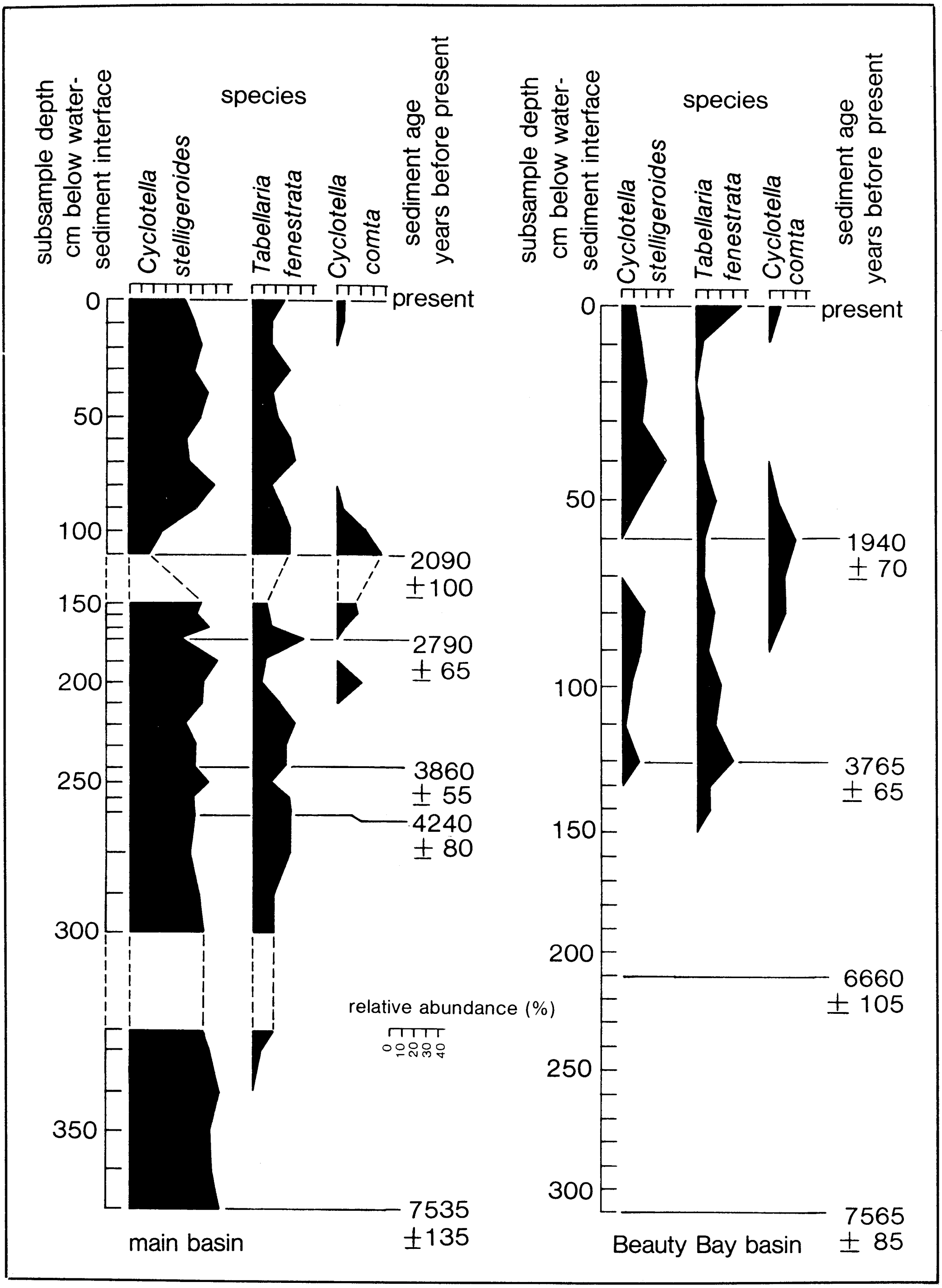

Fig. 2. Species that appeared in three or more subsamples at ≥3% relative abundance in the sediments of the main basin of Pine Lake, and their abundances in the Beauty Bay basin. Sediment age rather than subsampling interval is on the linear scale. Each horizontal hash represents one subsample. Subsamples were taken every 10 cm along the cores. Sediment ages are uncorrected ^{14}C dates.

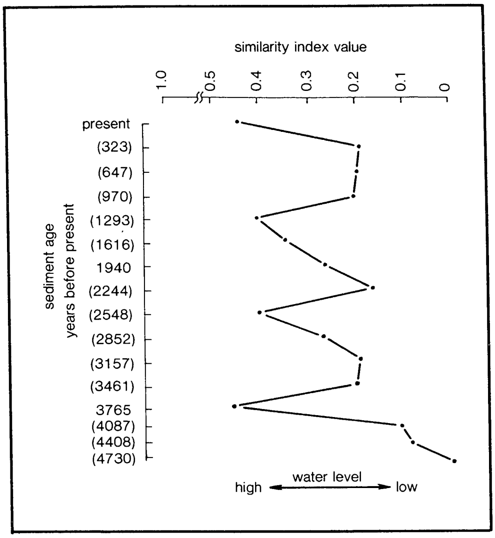

Fig. 3. Inferred water level fluctuations of Pine Lake over the past 5000 years. Similarity is based on a 2w/(a + b) index. Sediment ages in parentheses were determined by linear interpolation between ^{14}C dates. Those dates not in parentheses are uncorrected ^{14}C dates.

sediments were mixed on a small scale, to the order of tens of years (Davis and Smol 1986), it is unlikely that events on the scale of hundreds of years would be masked (Haworth 1980). The physical features of Pine Lake, in conjunction with the stable diatom community, also support an assumption of minimal disturbance of the sediments at the study site.

Eroded and broken frustules commonly occur in fossil diatom material. To test the extent of increasing dissolution and breakage over time all diatom valves and fragments with radial symmetry, identifiable to species or not, were counted on a sequence of eight microscope slides spanning the entire main basin core. On each slide at least 60 specimens were tabulated. Radial symmetry was used as the criterion because *C. stelligeroides,* a small radially symmetrical species, was the major prevalent in every core subsample. A ratio of "identifiable valves" to a total count, including "specimens not identifiable," ranged only from 0.765 to 0.821 with no trend detected from top to bottom of the core. Although it is obvious that a totally eroded valve is impossible to detect, it would be expected that valves eroded to the point of no longer being identifiable would increase with depth if dissolution over time were a problem. This did not seem to happen in Pine Lake, at least during the last 7500 years.

The remarkable simplicity and constancy of the diatom community of the main basin over the past 7500 years are evidence that any water-level fluctuations had little effect. The fact that there were only three prevalents, *C. stelligeroides, C. comta,* and *T. fenestrata,* which usually comprised 80% of the counts of 500 at all levels examined in the main basin, emphasizes this point. This has been attributed to several characteristics of the Pine Lake basin and its watershed. The lake's position in the very headwaters of the drainage was important because it limited the area that any surface drainage disturbance could affect. The steep slopes of the sides of the lake bed gave Pine Lake a large volume in relation to its surface, which diluted incoming nutrients. Although fire and windthrow undoubtedly hit the drainage basin, the results of these forces would have been patchy and irregular due to the uneven nature of the surrounding moraine. In any case, disturbed forested watersheds provide a surge of nutrients but rapidly recover (Borman et al. 1974). Pine Lake was able to absorb any short-term surges without showing detectable effects. Even post-European settlement disturbances, restricted apparently to logging and summer home development, produced minimal changes. In short, Pine Lake probably had minimal watershed disturbance and was well insulated from any disturbances that did occur.

Apparently the three main basin diatom

species thrived only in the open water of the main basin since, in the subsamples dated c. 7500 BP to 4500 BP examined from Beauty Bay when the two basins were inferred as being separate, not a single specimen of *C. stelligeroides, C. comta,* nor *T. fenestrata* was found. It was not until c. 4500 BP, and continuing to the present, that these three species appeared in Beauty Bay as prevalents. Even if isolated from the main basin, the proximity of Beauty Bay makes it unlikely that accidental introduction and establishment in the basin could have been avoided for the 3000 years prior to 4500 BP if water conditions were favorable. Whether they actually thrived after this time or were merely resupplied by water flow, it is probable that the presence of the three main basin prevalents in Beauty Bay for the last 4500 years was due to significant influx of water from the main basin.

Some information is always lost when raw data is condensed. In Pine Lake, the reference basin (main basin) had only the same three prevalent species in all subsamples of the core. Since the remaining nonprevalent species not used in the analysis, amounting cumulatively to less than 20% of each count of 500, were divided among at least 30 additional species at each sediment level examined, it is unlikely that the abundance of any one of these species, or even several of them, would materially affect the similarity comparisons to Beauty Bay. This is reinforced by the index itself, which treats each individual equally and does not give weight to species out of proportion to their abundance (Kershaw 1968). Variations in similarity values of equivalently aged main basin-Beauty Bay subsamples would thus be a function of the degree of "contamination" of Beauty Bay with the three main basin prevalents.

It should be mentioned that Beauty Bay had a great many other prevalents (unpublished data), but since the focus was on Beauty Bay "contamination" by main basin species and not on the community dynamics of Beauty Bay itself, this would not create a problem—as long as productivity in Beauty Bay remained relatively constant. To determine roughly if major changes in productivity took place since the inferred water level rise that united the two basins around 4500 years BP, preliminary counts of 500 valves each for three sediment subsamples from Beauty Bay within this span were examined. *Pinnularia biceps* Greg. was recorded at 9.2%, 16.3%, and 22.5% relative abundances at 0 years BP (0 cm), c. 1616 years BP (50 cm), and c. 3157 years BP (100 cm), respectively; *Synedra tenera* W. Sm. was recorded at 8.5% relative abundance at 0 years BP (0 cm); and *Navicula pupula* v. capitata Skv. and Meyer was recorded at 8.2% and 10.7% relative abundance at c. 1616 years BP (50 cm) and c. 3157 years BP (100 cm), respectively. No other species, besides the three main basin prevalents, were found in greater than 5% relative abundance during this time. The maintenance of only the same six most common species over the past 4500 years would indicate that productivity did not greatly change during this time.

Prior to c. 4500 years BP the diatom community of Beauty Bay was quite different. Instead of the six species cited in the previous paragraph, *Stauroneis anceps* Ehr., *Melosira islandica* O. Mull., *Melosira italica* (Ehr.) Kutz., *Fragilaria construens* v. *venter* (Ehr.) Grun., *Synedra famelica* Kutz., and *Fragilaria brevistriata* Grun. were most prevalent, all reaching greater than 10.0% relative abundance at one time or another in the preliminary counts (unpublished data). A major difference like this would be expected if the two basins were separate prior to 4500 years ago and united after that time.

Based on the degree of similarity between the Beauty Bay and Pine Lake diatom communities and roughly a 300-year sampling interval, dependent on sedimentation and compaction rates, the following sequence of surface fluctuations were inferred (Fig. 3):

1. From 7500 to c. 4500 years BP, the water table was low enough to keep the Beauty Bay basin separated from the main basin by a ridge. During this time span there were no main basin prevalents found in the Beauty Bay basin.

2. At c. 4400 BP main basin prevalents were first found in Beauty Bay and by 3765 BP the two communities had a similarity index of 0.469. This is comparable to the 0.444 index at present. Once the barrier between basins had been overcome at c. 4400 BP the lake level stabilized near its present level.

These first two inferences concur with the existence and timing of a Middle Holocene dry period, discussed by Winkler et al. (1986) and supported by 19 regional studies cited by them as evidence for this dry period.

3. Since 3765 BP the level has fallen and risen three times at the scale investigated. High levels occurred approximately every 1300 years as determined by linear interpolation between ^{14}C dates. The two intervening high points had similarity indices of 0.408 and 0.412.

4. The lowest water levels after the two basins were united, around 4500 years BP, centered around 3200, 2200 and 600 years BP. The similarity indices at these three times were 0.191, 0.157, and 0.197 respectively.

5. Since c. 4500 years BP, water levels have not been low enough to reisolate Beauty Bay, nor high enough to put the mouth bar under much more water than at present. The bar is now under one meter of water, so the surface level of the lake has varied less than one meter in elevation for any extended period during this time.

Acknowledgment

We thank the members of the Pine Lake Association whose contributions made this study possible.

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The "New Geology" and its Association with Possible Oil and Gas Accumulations in Wisconsin

Albert B. Dickas

The history of exploration for petroleum in the United States can be subdivided into distinct intervals based upon the prevailing philosophy employed in such exploration. Since the initial discovery of crude oil in the United States among the rolling hills outside Titusville, Pennsylvania, by "Colonel" Edwin Drake in 1859 (Hubbert 1966), the processes of exploration for this commodity have been under continual scrutiny. Numerous scientific, and some decidedly not so scientific, theories regarding the origin, migration, and accumulation of subsurface oil and gas have been advanced. One of the earliest, the concept of "creekology," suggested crude oil was to be found underlying areas of principal surface drainage. The anticlinal theory, advocated by White (1885), associated petroleum accumulation to the upper reaches of rock folded by compressional or other forces.

On the 10th day of the twentieth century, the Spindletop field discovery well was brought in along the Texas Gulf Coast, flowing out of control at the rate of 100,000 barrels of crude oil per day. Immediately wildcatters sought means of effectively identifying subsurface salt-domes, miles-high intrusions of rock salt that seemed to trap oil and gas unlike any other geologic phenomena. Other exploration hypotheses of temporary significance have included low angle (over-thrust) displacement belts and anomalously high energy-wave (bright-spot) analysis.

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During the peak of each new orthodoxy, a different geographic sector of the country obtained the prosperity attendant upon the expanding oil and gas industry. For example, the anticlinal theory of exploration was responsible for the expansion of the American oil industry westward from the Keystone state into the Ohio River Valley during the late nineteenth century. Unfortunately this movement never reached Wisconsin. Attempts were made; in fact 56 wells have been drilled since 1865, but all were "dry and abandoned" (Fig. 1). By World War II Wisconsin had been written off, declared lacking in commercial petroleum-discovery potential because the rock strata were considered geologically too old for petroleum generation.

Consistency of change is one of few undeniable absolutes, and it was only a matter of time until a new concept of geologic exploration should focus upon the ancient terranes of Wisconsin, and indeed, did so in Bayfield County in the Autumn of 1983. Agents representing major American corporations began leasing private and public lands for petroleum exploration. During 1984 and 1985, geophysical crews conducted seismic, gravity, and magnetic surveys in northwestern Wisconsin. Why, after a century and a quarter, had these lands become the focus of such costly attention? The answer is to be found in the annals of geologic debate that raged internationally from approximately 1900 until 1966. Two topics are of

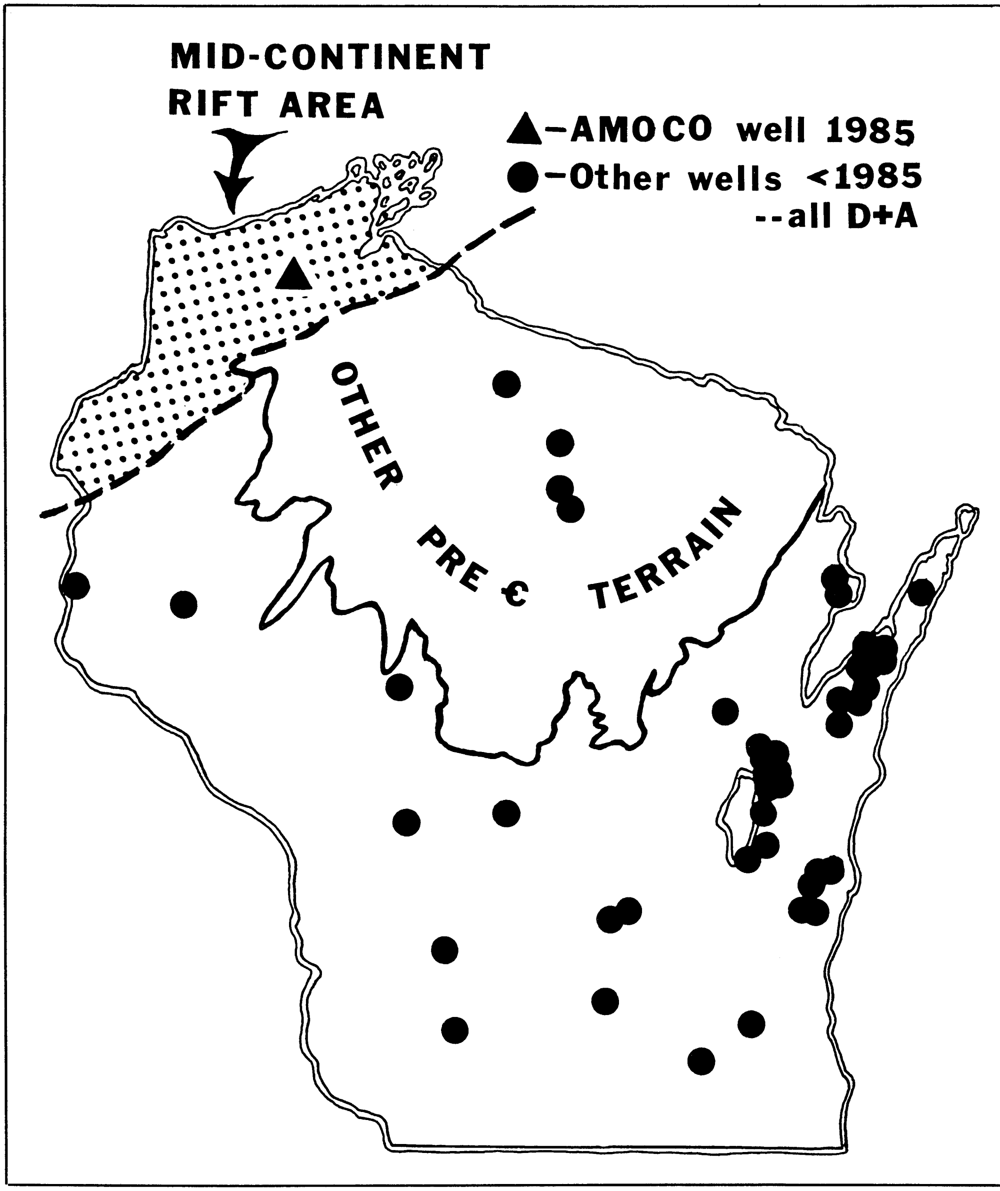

Fig. 1. Wells drilled for oil and/or gas prior to 1985 in Wisconsin. All were declared dry and abandoned by operator.

significance. The first dealt with "solving the mystery of the Earth" (Wood 1985), or more precisely, the identification of forces responsible for first-order surface features—continents, ocean basins, and mountain ranges. The second scientific debate involved the question of when life on Earth originated.

Plate Tectonics

The solution of the great Earth mystery suffered from schismatism. One school of knowledge depended upon a fixist state whereby Earth gradually constructed its surface morphology through periodic vertical movements caused by crustal contraction. In opposition stood the mobilists, arguing for horizontal crustal motion according to the recent discoveries, by Henri Becquerel in 1896 and Pierre and Marie Curie in 1903, of the processes of radioactivity (Eicher 1968). The fixists perceived our planet as dying, with its endowed internal engine gradually slowing as a result of irretrievable conductive loss of heat power. The mobilists argued that conductive loss was being replaced by new heat volumes derived through the newly discovered elemental radioactive decay.

In 1915 Alfred Wegener, a German meteorologist, geophysicist, and explorer of Greenland, published "Die Entstehung der Kontinente und Ozeane" (On the Origin of Continents and Oceans), a unifying theory of earth-crust motion bound by mobilistic concepts of his own derivation. While ultimately silencing the fixist school of thought, this "continental drift" theory over the next several decades became increasingly mired in controversy among geoscientists, physicists, chemists, and mathematicians. Consolidated by opposition status quo defenses of a lack of proof of continental movement and frictional forces of impossible magnitudes, the drift theory slowly lost relevance with the death of Wegener on the Greenland ice-cap in 1930 and the approach of a worldwide depression and war.

In the aftermath of that war, Wegener's ideas were again seriously discussed by geoscientists employing new analysis techniques. The fathometer (depth recorder) and magnetometer (magnetic field analyzer) had been technologically modified and miniaturized early in World War II for anti-submarine surveillance. With the arrival of peace these instruments, along with the ships and aircraft upon which they were mounted, were declared surplus by the military and adopted for use by a generation of fledgling oceanographers unfettered by older scientific theories.

By the late 1950s Maurice Ewing, Bruce Heezen, and Marie Tharp, among many others, working out of the Lamont Doherty Geological Observatory in downstate New York, had gathered sufficient depth data to present an artist's view of the ocean floors (Heezen et al. 1959). Startling in their appearance, these charts for the first time displayed a ridge and rift system, generally occupying a central position that could be traced worldwide from the Indian to the Atlantic to the Pacific Ocean (Fig. 2). Within the next decade, coalescing scientific discoveries began to complete the picture. Previously disjointed masses of paleontological, gravimetric, paleomagnetic, and petrographic data now came together in the minds of physicists, biologists, and geologists as one unified theory. By 1966, the "mystery of the Earth" had been identified, and Wegener had been vindicated in his belief that a precise analysis and understanding of rocks, their structures, and fossils would require very different arrangements of the continents in the past than those of the present (Schwarzbach 1986). In this updated version the phrase "continental drift" had been altered in the best interests of scientific nomenclature to "plate tectonics." Since the mid-1960s plate tectonics has caused a major academic revolution within the earth sciences, with the result that most practicing petroleum geologists have altered their techniques of applied oil and gas exploration.

Life on Earth

The second great development in scientific philosophy important to the commercial oil or gas potential in Wisconsin is the debate on the origin of life on Earth. Rocks outcropping over much of Wisconsin are Precambrian in age; that is, they were deposited in their present position in excess of 570 million years ago. To many geologists, Precambrian rock is seen as

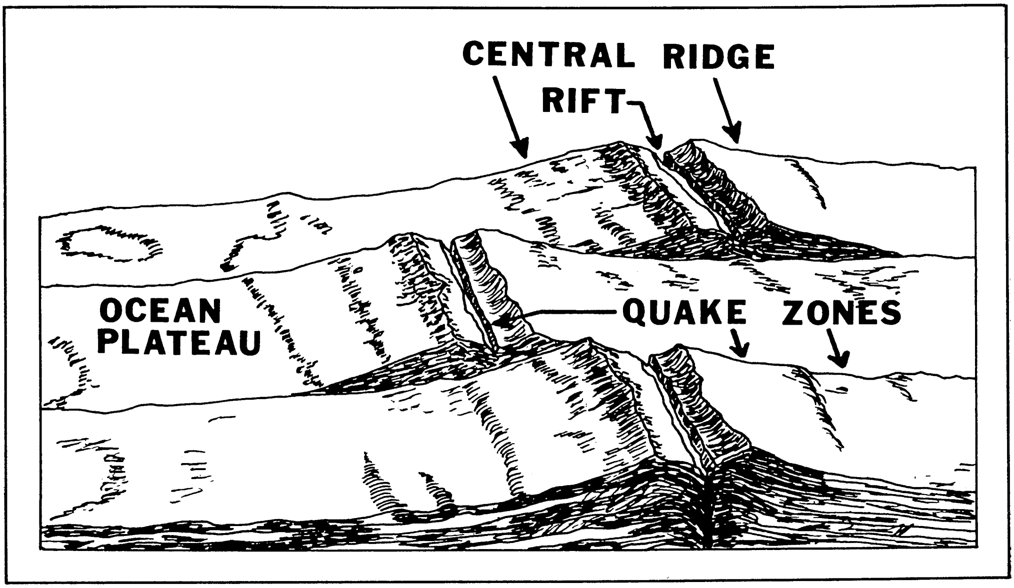

Fig. 2. Artist's view of the topography of the ocean floor showing relative locations of centrally positioned ridge and rift.

the end geologic product of thousands of millennia during which turbulent events created earth environments entirely unfavorable to the ultimate development of petroleum and natural gas. As recently as two decades ago it was believed that prolonged earth movements and periods of rock deformation, both characteristic of the Precambrian era, did not permit the evolution or preservation of life forms. Jones (1956) emphasized this bias by stating that "the recognition of evidence of life in Precambrian strata is one of the most controversial problems in all geology and there is considerable doubt expressed by many paleontologists concerning the nature of the micro-fossils which have been reported." Similar statements aided in the development of anti-early-life philosophies that have been prevalent among many petroleum geologists. However, this early learned bias is rapidly disappearing with the acceptance that the appearance of life was an early development in Earth history and that fossiliferous, organic-rich sedimentary rocks form a significant portion of the Precambrian stratigraphic record (McKirdy 1974). Since the 1950s fossils have been discovered in rock as old as 3.5 billion years in South Africa (Levin 1988), Australia, the Soviet Union, and along the north shore of Lake Superior (Tyler and Barghoorn 1954); it has been shown that this primordial organic material does not differ in any respect from that which is much younger as a potential source material for oil or gas (Fig. 3). The East Siberian Platform (Irkutsk Amphitheater) Petroleum Province, USSR, contains the largest known reservoirs of indigenous Precambrian gas, oil, and condensate (Meyerhoff 1980). More than ten commercial fields have been reported since 1962 from this isolated sector of the Soviet Union, all of which contain at least one reservoir horizon within the Precambrian section (Fig. 4). The oldest of these strata are approximately 925 million years old. In 1963, The Ooraminna #1, a 1861 meter (6,100 feet) test of Precambrian rocks, was drilled in the Amadeus Basin of Australia. While a production test flowed at an uneconomic

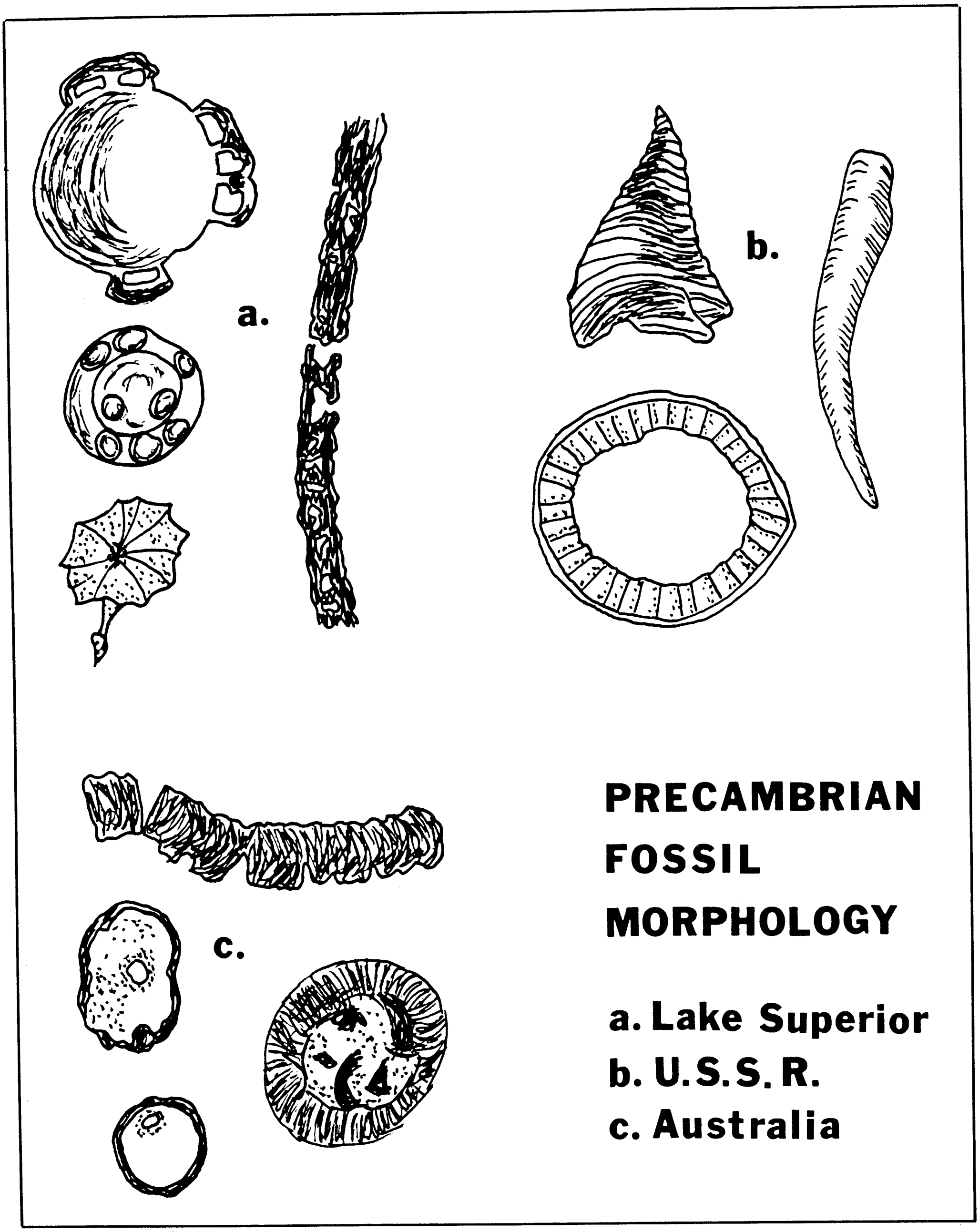

Fig. 3. Examples of fossil morphology from rocks of Precambrian age as collected on three continents. (After Raup and Stanley 1971; Levin 1988).

12,000 cubic feet of natural gas per day, this well was a resounding geologic success as it constituted "irrefutable evidence of indigenous hydrocarbons in the Precambrian of Australia" (Murray et al. 1980). Recent exploratory drilling in Australia discovered "live oil, possibly the oldest oil in the world," in rocks 1.4 billion years of age (Fritz 1987). In 1964, the discovery well for the Weiyuan gas

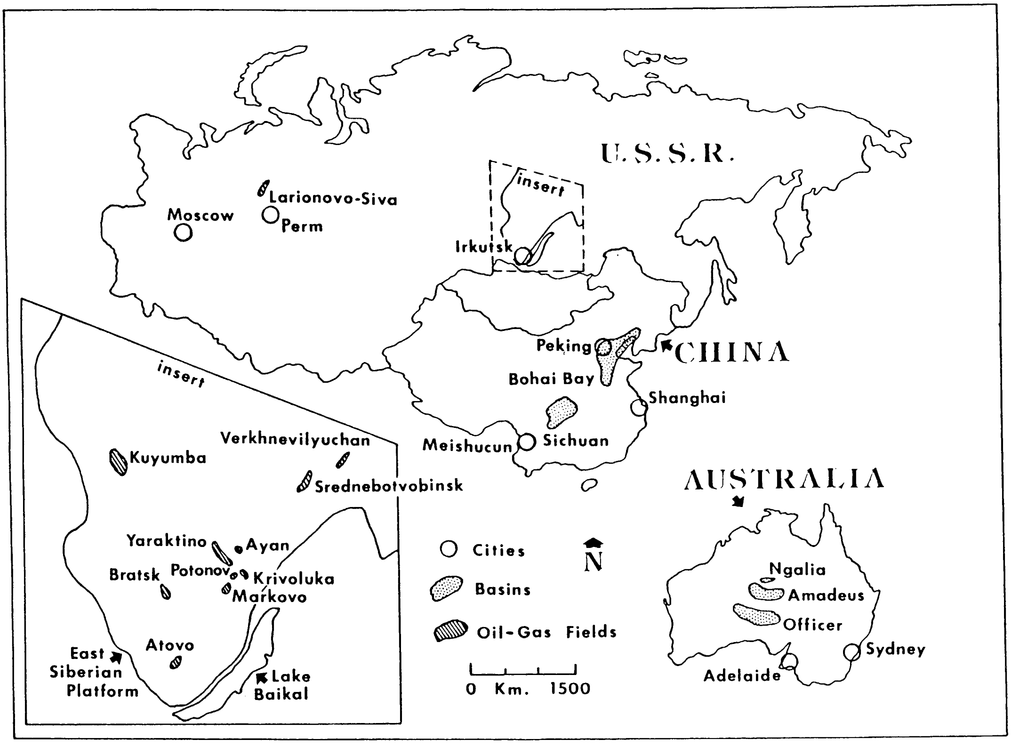

Fig. 4. Commercial oil and/or gas fields in China, Australia, and the USSR in which production is derived from Precambrian-age rocks.

field in the central Sichuan Basin of the People's Republic of China was announced (Fig. 4). Here the principal producing interval lies within the Dengying Formation of Upper Sinean (late Precambrian) age (Shicong et al. 1980).

In the short span of three years during the early 1960s, decades of prejudice against hydrocarbon association with Precambrian strata were overcome. Not only has Precambrian life been generally accepted (Cooper et al. 1986), but so has the economic significance of rift structures created through the dynamics of plate tectonics. Either one or both of these concepts were responsible for the petroleum discoveries in the USSR, Australia, and China. In the early 1980s several entrepreneurs employing these "new geology" concepts as their principal exploratory philosophy began to view northern Wisconsin with enthusiasm. These individuals were interested in the Midcontinent Rift, a geologic structure known principally through geophysical research and considered an ideal field analog to the features formed by extensional plate tectonics.

Midcontinent Rift

The Midcontinent Rift is an ancient crustal scar, first identified in subsurface rocks in northwestern Kansas (Woollard 1943) and traceable by analysis of earth's gravity field for 1,400 kilometers (870 miles) north and east across Iowa, Minnesota, and into northern Wisconsin (Fig. 5). There, the rift trend branches along the north and south shores of Lake Superior. This scar is evidence of Precambrian pressures operating within the mantle of the Earth. These pressures began to divide the early version of the North American continent into two distinct land

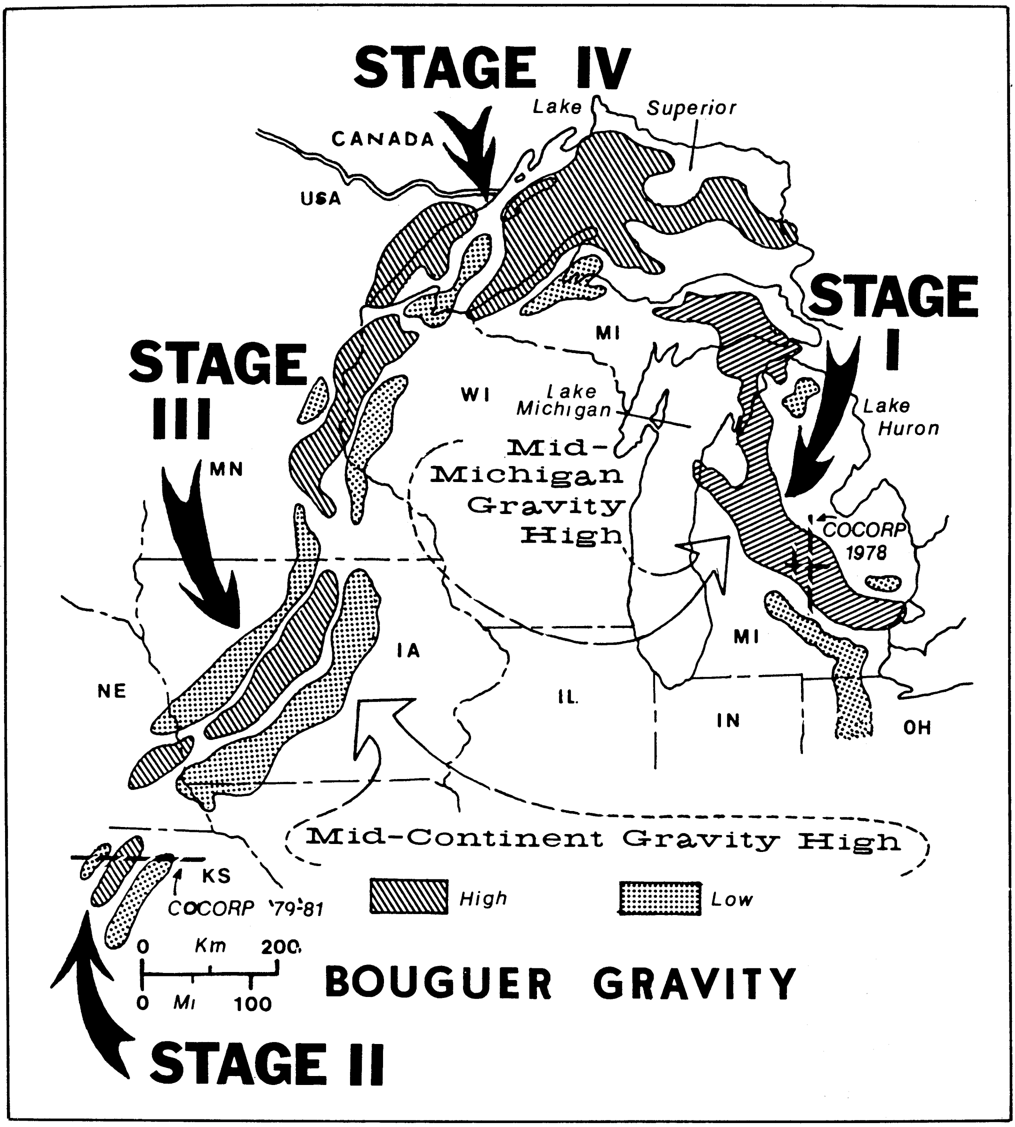

Fig. 5. Trend of the Midcontinent Rift System in the central United States as identified by the Bouguer component of the Earth gravity field. Shown is the geographic extent of the four stages of geologic development which together compose the entirety of the rift (modified from Dickas 1986).

masses. Initiated approximately 1.1 billion years ago, these gigantic tectonic movements increasingly bifurcated the land for some 50 million years. Then, with a maximum separation measuring 60–70 kilometers (40–44 miles), the internal forces dissipated, and the rift gradually healed itself.

While undergoing plate tectonic spasms, the rift served as a conduit for the expulsion of thousands of feet of lava onto the surface of the Earth. These lava fields today can be traced over 100,000 square kilometers (39,000 square miles) of both the north and south shores of Lake Superior (Green 1982). Here, they form the basement upon which younger sedimentary rocks ultimately were deposited. This post-lava series of strata, included in the Keweenawan Supergroup (Morey and Green 1982), is more than 7,600 meters (25,000 feet) thick and can be found outcropping along the river bottoms and shorelines of Douglas, Ashland, and Bayfield counties (Dickas 1985 and 1986). It is this accumulation of sandstone, siltstone, and regionally distributed organic shale, deposited in rifted basins, that has drawn the recent interest of oil and gas explorationists.

A three-dimensional model of the Midcontinent Rift in northern Wisconsin would be constructed of three rectangular slabs, lying side by side (Fig. 6). The central block would be elevated relative to the flank blocks. Initially these slabs would be composed of basaltic (lava) rock. Over the central, or horst block, a lens-shaped volume of lightweight material (sandstone and shale) replaces that portion of the lava rock lost to ancient erosion. The flank blocks are covered rather uniformly by thick layers of similar low density rocks, protected from erosion by their depressed elevation. Finally all three slabs are covered by a thin veneer of unconsolidated sediment representing glacial accumulations of the past several thousand years.

The Rock Character

Rift structures of Precambrian age have been proven to have economic petroleum potential elsewhere in the world, but to date no oil or gas reserves in this country are known to be associated with rift rocks, regardless of their geologic age. While philosophical freedoms allowed by "new geology" theories encouraged explorationists to enter northern Wisconsin in 1983, commercial success in our state will ultimately depend upon the subsur-

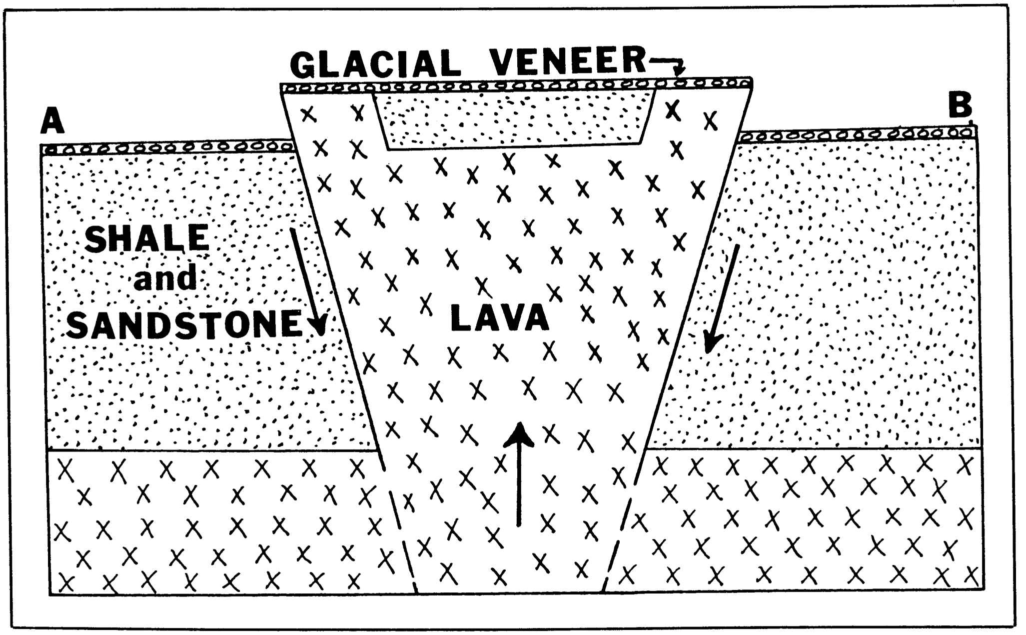

Fig. 6. Cross-sectional model of the Midcontinent Rift for northern Wisconsin. Orientation is A (area of Superior) southeast to B (area of Hayward). Arrows represent relative movement of major geologic blocks.

face physical characteristics of the Keweenawn Supergroup strata.

Such success relies on the presence of three geologic conditions: (1) an organic-rich rock that acts as the source of petroleum; (2) an adjacent and permeable rock that allows concentration of migrating petroleum into an economic accumulation; and (3) another adjacent but impermeable rock that prevents the accumulated petroleum from being lost by migration to the surface. In the vicinity of the Wisconsin-Michigan border a source rock is known. Identified in the 1880s (Irving 1883), the Nonesuch Shale is rich in organic matter and actually drips small quantities of crude oil through the ceiling-rocks of the White Pine copper mine of Michigan's Upper Peninsula. This source rock has been traced westward into the Lake Nebagamon region of Douglas county, Wisconsin, but its presence further southwest along the Midcontinent Rift is a matter of speculation.

The presence in northern Wisconsin of rock capable of pooling and trapping hydrocarbons is also speculative. The primary purpose of the seismic, magnetic, and gravimetric analyses conducted on land during 1984 and offshore Lake Superior during 1985 was to indirectly ascertain and qualify these characteristics.

The Future for Wisconsin

Between the Autumn of 1983 and end of 1985 an estimated four to five million dollars was spent on geological and geophysical evaluation of hydrocarbon potential in northern Wisconsin. A 3,660 meter (12,000 foot) test well was announced by Amoco Production Company (USA) in 1985, to be located in Bayfield County (Fig. 1). Soon after, however, the price of a barrel of crude oil collapsed from $25 to less than $9, placing all drilling programs "on-hold." The American oil and gas industry entered a negative economic cycle that produced unemployment and lowered exploration expenditures to levels not experienced since the great depression of the 1930s. In spite of this unprecedented event, most drilling leases in northern Wisconsin have been maintained by the companies who have established positions in this area, and all are watching the slow, long-term recovery of the price of a barrel of crude oil.

All scientific endeavors require an amount of luck to reach successful conclusions. This is no less true for Wisconsin's potential as an oil or gas-producing state. Should such potential be realized within the next several years, credit must be given to the numerous researchers worldwide who amalgamated the recently developed theories of Precambrian life and rift tectonics into "new geology" philosophies of petroleum exploration.

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Use of Discriminant Analysis to Classify Site Units Based on Soil Properties and Ground Vegetation

John R. Trobaugh and James E. Johnson

Abstract. *Ten forested plots were located in each of three site units in northeastern Wisconsin. The site units selected for study, Padus, Pence, and Vilas, reflect a range in productivity from high to low based on soil-site equations for red pine (*Pinus resinosa *Ait.). Soil physical and chemical properties and percent frequency of ground flora were used as independent variables in a canonical discriminant analysis to separate the site units. The percent correct classifications were as follows: soil variables only, 67%; vegetation variables only, 57%; soil and vegetation variables 83%. The strongest soil discriminator variables generally reflected finer textures and higher nutrient content associated with the Padus units, while the strongest vegetative discriminators indicated either the more mesic, nutrient rich Padus sites (*Viola *spp.,* Polygonatum biforum *(Walt.) Ell., and* Dryopteris spinulosa *[O.F. Mull.] Watt.) or the dry, acidic Vilas sites* (Gaultheria procumbens *L.,* Vaccinium angustifolium *Ait., and* Waldsteinia fragarioides *[Michx.] Tratt.).*

Classification of forest land into distinct units is currently an important area of research and development in the U.S. Two recent symposia (Bockheim 1984, Wickware and Stevens 1986) have included numerous papers dealing with the development of classification systems and associated methodologies. Systems in common use in the U.S. include single factor systems such as soil surveys (Arnold 1984) and habitat typing (Kotar and Coffman 1984), and multifactor systems such as ecological forest site classification that considers climate, geology/parent material, physiography, soils, and vegetation (Barnes et al. 1982).

An important aspect of land classification is that the site units must be recognizable on the landscape and must represent somewhat homogeneous soil and vegetation conditions. In order to be useful for management purposes the units must also reflect differences in productivity and management interpretations (Barnes et al. 1982).

Both the single and multifactor approach are being used in forested areas of Wisconsin. In order for these systems to reflect differences in productivity and management interpretations, studies are needed to determine the amount of variation within site units. This study was established to determine (1) the variation among soil properties and ground vegetation within site units and (2) the importance of these variables in discriminating among three common site classification units in northeastern Wisconsin.

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Methods

Study Area

The study area was located in Oneida and Forest Counties, Wisconsin (Fig. 1). This area is located within a single homogeneous macroclimatic zone (Rauscher 1984), with the following climatic features: average annual maximum temperature 11.2°C, average annual minimum temperature −0.6°C, average frost free season from 87 to 117 days, average annual precipitation 782 mm with 60% falling during the growing season, and an average annual snowfall of 1,397 mm.

Throughout the study area the bedrock is undifferentiated crystalline rock of pre-Cambrian age, overlain by glacial drift deposited during the Woodfordian Substage of the Pleistocene. Most of the glacial deposits are sorted, stratified, glaciofluvial sand and gravel. The topography is primarily pitted and unpitted outwash; however, study plots were generally located on level landscape positions.

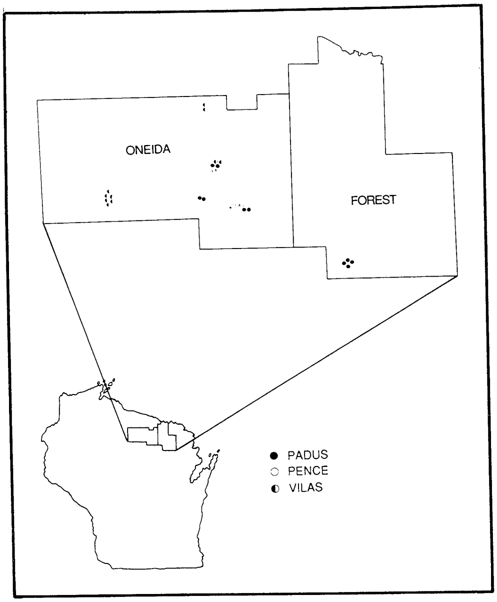

Fig. 1. Study area in northeastern Wisconsin.

Site Units

The forest land classification units selected in this study were generally defined as site units and are similar to the Ecological Land Types (ELT's) used by the Nicolet National Forest (Nicolet National Forest 1983). These site units have similar landform and climatic conditions, but differ in soil and vegetation features. The three site units were all located on glacial outwash plains or uplands within the two county study area. The site units, named for the predominant soil series found in each, have the following features:

Site Unit	*Soil Series*	*Soil Taxonomic Classification*	*Habitat Type (Kotar 1986)*
Padus	Padus	Alfic Haplorthod (coarse-loamy, mixed, frigid)	*Tsuga-Maianthemum*
Pence	Pence	Entic Haplorthod (sandy, mixed, frigid)	*Tsuga-Maianthemum-Vaccinium*
Vilas	Vilas	Entic Haplorthod (sandy, mixed, frigid)	*Acer-Quercus-Vaccinium*

These site units represent a range of site productivity from high (Padus) to low (Vilas) as follows:

Site Unit	*Mean Red Pine Soil-Site Index Alban (1976)*	*Standard Deviation of Soil-Site Index*
	--------- m	---------
Padus	18.4	0.9
Pence	16.7	0.4
Vilas	16.5	0.4

All three are especially important throughout the study area because they are commonly converted from the existing cover type to pine plantations. The level landscapes and sandy soil textures generally make these site units well-suited for site conversion and pine plantation management.

Field Methods

During the summer of 1984 ten Padus, ten Pence, and ten Vilas site units were identified within the study area. Within each unit a circular 100 m^2 plot was located, and all trees greater than 12.7 cm in dbh were tallied by species, dbh, and height. On a nested 25 m^2 plot all trees between 2.5 cm and 12.7 cm dbh were recorded by species. On a nested 4 m^2 plot all woody stems less than 2.5 cm dbh and 1 m in height were recorded by species and percent canopy cover. Woody vegetation measured on these plots roughly corresponded to the overstory, upper understory, and lower understory strata. On 12 systematically located 1 m^2 plots all ground herbaceous and woody vegetation (less than 1 m tall) was recorded by species, and percent frequency was calculated.

Adjacent to each 100 m^2 plot a 1 by 1.5 m soil pit was dug to the C horizon. A complete field description was conducted, including horizon designation, horizon depth, color, texture, structure, pH, mottle identification, and consistence. Soil samples from each horizon were collected from the soil pit and from four additional auger samples taken near the plot. These five samples were then composited into a single sample for the plot. Four forest floor samples were collected from the vicinity of the pit. These samples were separated into Oi + Oe and Oa horizons and then composited by horizon.

Lab Methods

All soil samples were air-dried, ground to pass a 2-mm sieve, and subjected to the following physical and chemical analyses: 1) particle size analysis using the hydrometer method (Day 1965), 2) total nitrogen using micro-Kjeldahl (Bremner 1965), 3) available phosphorus using the ammonium molybdate method following extraction in 0.025N HC1 and 0.03N NH_4F, 4) the same extract was used to determine available potassium using a flame photometer following the same extraction procedure as for P, 5) exchangeable calcium and magnesium by flame photometry following extraction in 1N NH_4OAc (Liegel et al. 1980), 6) pH using a glass electrode with 7.5 g soil in 10 ml of distilled water, 7) organic matter content using the Walkley-Black method (Walkley and Black 1934), and 8) buffer pH using the method of Shoemaker et al. (1961).

Forest floor samples were dried to a constant weight at 65°C. Samples were then weighed and ground to pass a 1-mm sieve. Total nitrogen was determined using micro-Kjeldahl (Bremner 1965), and total phosphorus, potassium, calcium, and magnesium were determined using an ARL plasma emission spectrophotometer following digestion in concentrated nitric and perchloric acid (Liegel et al. 1980).

Statistical Analysis

The three site units were used as qualitative groups and suites of 53 soil variables and 60 ground vegetation species were used as discriminator variables in a canonical discriminant analysis (Klecka 1980). Variables considered to be independent were selected for analysis. The analysis was conducted using the soil variables, vegetation variables, and the two combined. The jackknife method was used to determine the percentage of correct classification following each discriminant analysis. The jackknife method is recommended when sampled size is small relative to the number of variables (Lachenbruch and Mickey 1968). Using this method, one plot at a time was withheld from the data set, and the discriminant function was derived from the remaining 29 plots. Independent variables from the withheld plot were used to calculate the site unit classification. This procedure was repeated for each of the 30 plots, and the percent correct classification was determined.

Analysis of variance and mean separation using the Sheffe test at the 0.05 probability level were used to determine significant differences between the soil and vegetation discriminator variables.

Results and Discussion

Site Unit Vegetation

All plots located on the three site units were forested (Table 1), with pines, aspen-birch, spruce-fir, and red maple (*Acer rubrum* L.) predominating in the overstory. The plots on the Pence site units had the highest basal area and number of stems/ha, followed by the Padus and Vilas site units. The upper understory, however, was densest on the Padus site units, followed by the Vilas and Pence site units (Table 2). The lower understory was dominated on all site units by beaked hazel (*Corylus cornuta* Marsh.), but was densest on the Vilas site units (Table 3). Curtis (1959) identified beaked hazel as the most common shrub species in the northern mesic forests of Wisconsin, and is commonly considered a strong competitor to tree regeneration in these stands (Buckman 1964).

Site Unit Soil and Forest Floor Properties

Soil physical and chemical properties for representative profiles from each of the site units are shown in Table 4. The Padus soils tended to be finer-textured and higher in nutrient content than the Pence and Vilas soils. In general, the Padus site units reflect soil conditions typical of Curtis' (1959) northern mesic forest, the Pence site units are typical of the northern mesic/dry-mesic forest, and Vilas site units are typical of the dry-

Table 1. Mean overstory number of stems/ha, basal area/ha, and dominant species of second-growth forests on three site units in northeastern Wisconsin.

Site Unit	*Age*	*No. Stems/ha*		*Basal area (m²/ha)*		
	yrs.	$\bar{X}$	*SD*	$\bar{X}$	*SD*	*Dominant Species*
Padus	60	770	337	23.8	7.4	*Acer rubrum* L. *Betula papyrifera* Marsh. *Pinus resinosa* Ait.
Pence	63	840	365	33.1	10.7	*Betula papyrifera* Marsh. *Populus grandidentata* Michx. *Abies balsamea* (L.) Mill. *Pinus resinosa* Ait. *Picea glauca* (Moench) Voss
Vilas	60	580	344	24.7	11.7	*Pinus strobus* L. *Pinus resinosa* Ait. *Quercus rubra* L. *Populus tremuloides* Michx. *Pinus banksiana* Lamb.

$\bar{X}$ = Arithmetic mean SD = Standard deviation

Table 2. Mean upper understory number of stems/ha, basal area/ha, and dominant species of second-growth forests on three site units in northeastern Wisconsin.

Site Unit	*No. stems/ha*		*Basal area (m^2/ha)*		
	$\bar{X}$	*SD*	$\bar{X}$	*SD*	*Dominant Species*
Padus	1160	573	4.6	3.6	*Betula papyrifera* Marsh. *Acer rubrum* L. *Acer saccharum* Marsh. *Abies balsamea* (L.) Mill
Pence	680	672	3.5	1.8	*Abies balsamea* (L.) Mill *Picea mariana* (Mill.) B.S.P. *Betula papyrifera* Marsh. *Picea glauca* (Moench) Voss *Prunus serotina* Ehrh.
Vilas	720	460	2.6	2.1	*Abies balsamea* (L.) Mill *Acer rubrum* L. *Acer saccharum* Marsh. *Populus tremuloides* Michx. *Pinus banksiana* Lamb.

$\bar{X}$ = Arithmetic mean SD = Standard deviation

Table 3. Mean lower understory number of stems/ha, percent canopy cover, and dominant species of second-growth forests on three site units in northeastern Wisconsin.

Site Unit	*No. stems/ha*		*Canopy Cover (%)*		
	$\bar{X}$	*SD*	$\bar{X}$	*SD*	*Dominant Species*
Padus	7,500	6,435	25	16	*Corylus cornuta* Marsh. *Acer saccharum* Marsh. *Abies balsamea* (L.) Mill.
Pence	6,500	6,519	21	19	*Corylus cornuta* Marsh. *Prunus virginiana* L. *Abies balsamea* L. Mill.
Vilas	19,750	26,655	34	39	*Corylus cornuta* Marsh. *Abies balsamea* (L.) Mill. *Amelanchier arborea* (Michx. f.) Fern

$\bar{X}$ = Arithmetic mean SD = Standard deviation

Table 4. Soil physical and chemical properties from plots representing typical features of the Padus, Pence, and Vilas site units in northeastern Wisconsin.

Site Unit	Plot	Horizon	Depth (cm)	Color	Texture % sand	Texture % silt	Texture % clay	Bulk Density g/cm³	Nutrient Content (kg/ha) N	P	K	Ca	Mg	Organic Matter (t/ha)	pH
Padus	15	E	0-9	7.5YR 4/2	71	22	7	1.3	1,708	95	52	8.4	1.9	33.1	5.1
		Bhs	9-23	7.5YR 3/4	83	6	11	1.0	564	235	50	7.4	2.0	29.5	5.1
		Bs + Bt	23-54	10YR 4/4	59	31	10	1.0	894	304	153	14.4	4.3	47.9	5.1
											(mg/kg)			%	
		C	54 +	7.5YR 4/4	87	6	7	1.1	100	40	30	30	0.5	0.8	5.0
Pence	29	E	0-5	7.5YR 4/2	82	13	5	1.4	206	5	26	0.9	0.3	11.0	4.1
		Bhs	5-21	7.5YR 3/4	81	11	8	1.6	1,851	69	222	3.2	1.3	73.5	4.7
		Bs	21-42	7.5YR 4/4	87	8	5	1.6	466	98	125	1.7	1.7	30.0	4.9
											(mg/kg)			%	
		C	42 +	7.5YR 4/6	89	6	5	1.2	90	47	38	0.8	0.5	0.7	5.2
Vilas	26	E	0-4	5YR 3/2	85	10	5	1.1	267	5	20	0.6	0.5	13.1	4.3
		Bhs	4-17	7.5 YR 3/4	86	7	7	1.5	734	77	77	1.0	1.9	40.6	4.9
		Bs	17-42	7.5YR 4/6	89	5	6	1.5	670	259	118	1.9	2.8	33.5	5.0
											(mg/kg)			%	
		C	42 +	10YR 4/4	95	1	4	1.6	40	75	20	0.5	0.8	0.4	5.2

Table 5. Forest floor dry weight, depth, and nutrient content from plots representing typical features of the Padus, Pence, and Vilas site units in northeastern Wisconsin

Site Unit	Plot	Horizon	Depth (cm)	Dry wt. (t/ha)	Nutrient Content (kg/ha) N	P	K	Ca	Mg
Padus	15	Oi + Oe	1	6.6	125	11	11	120	12
		Oa	5	69.6	401	47	52	278	118
		Total	6	76.2	526	58	63	398	130
Pence	29	Oi + Oe	1	7.3	72	6	8	52	6
		Oa	3	95.7	490	44	69	230	56
		Total	4	103.0	562	50	77	282	62
Vilas	26	Oi + Oe	1	8.0	117	9	10	79	11
		Oa	3	57.0	477	38	56	208	56
		Total	4	65.0	594	47	66	287	67

mesic/xeric forest. The forest floor physical and chemical properties for representative site units are shown in Table 5. The Pence site unit had the forest floor with the greatest dry weight, but was largely intermediate in nutrient content. The Padus forest floor had the greatest P, Ca, and Mg, while the Pence forest floor had the greatest K and the Vilas had the greatest N.

Discriminant Analysis

The discriminant analysis resulted in three functions, one based on soil properties, one based on ground vegetation frequency, and one based on a combination of soil and vegetation variables. For site units to be considered useful, they must represent unique features of landforms, soils, or vegetation, or must have distinct management interpretations (Moon 1984). In this analysis common soil properties considered part of routine soil analysis and the existing ground vegetation were found to be effective in distinguishing among the three site units. This procedure was also useful in separating site units in Michigan, where a suite of eight soil and topographic variables and nine vegetation variables discriminated between 11 upland forest ecosystems on the McCormick Experimental Forest (Pregitzer and Barnes 1984).

The soil, vegetation frequency, and combined variables used in the discriminant analysis are presented in Tables 6–8. The 21 site, soil, and forest floor variables (Table 6) reflect a combination of physical and chemical properties, the most important of which is the soil-site index (Alban 1976). This value represents the calculated red pine site index based upon soil texture, depth, and the presence of fine-texture bands that may significantly influence tree growth (Hannah and Zahner 1970). It indicates a significant difference between the Padus and Pence site units but not between the Pence and Vilas. In general, the finer soil textures associated with the Padus site unit, coupled with higher soil and/or forest floor P, K, Ca, and Mg, resulted in strong discrimination between the Padus and other site units. Using the jackknife validation procedure, the predicted site unit membership was as follows: Padus, 80%; Pence, 50%; and Vilas, 70%, for an overall correct classification of 67%.

The presence of key species of vegetation have been shown to be strong indicators of edaphic factors in forest ecosystems (Pregitzer and Barnes 1982)

Table 6. Means, standard deviations (in parentheses), and F statistics for site and soil discriminator variables presented in order of stepwise inclusion for the Padus, Pence, and Vilas site units in northeastern Wisconsin.

Variables	F Prob.	Padus	Pence	Vilas
Red Pine				
Site Index (m)	0.0000	18.4 (0.9) a[1]	16.7 (0.4) b	16.5 (0.4) b
% Clay, E Horizon	0.0043	8.2 (2.8) a	6.3 (1.1) ab	5.2 (1.0) b
Mg, Oa Layer (kg/ha)	0.0062	85.4 (25.7) ab	105.1 (42.3) a	58.2 (15.6) b
pH, Bhs Horizon	0.0016	5.1 (0.1) a	4.8 (0.2) b	4.9 (0.1) b
K, Oi Layer (kg/ha)	0.3422	14.0 (4.3) a	11.7 (3.3) a	12.9 (3.0) a
Depth, Bs Horizon (cm)	0.0063	35.8 (12.0) a	25.4 (9.2) ab	20.9 (7.5) b
Depth, Bhs Horizon (cm)	0.7660	15.3 (5.5) a	15.8 (6.7) a	14.0 (4.5) a
% Clay, C Horizon	0.0041	7.4 (3.2) a	5.5 (1.3) ab	4.0 (0.9) b
SMP, Bhs Horizon	0.4634	62.4 (2.2) a	61.5 (1.6) a	62.3 (1.3) a
SMP, E Horizon	0.0093	66.5 (1.3) a	65.4 (1.5) ab	64.4 (1.4) b
P, Bhs Horizon (kg/ha)	0.9556	173.9 (133.5) a	153.2 (170.7) a	158.4 (173.3) a
% Silt, Bs Horizon	0.0000	29.8 (13.3) a	17.3 (7.0) b	8.1 (2.4) b
P, Oi Layer (kg/ha)	0.1391	12.2 (4.1) a	9.2 (2.9) a	10.5 (2.4) a
Ca, Oa Layer (kg/ha)	0.0088	360.9 (160.4) a	339.0 (93.1) a	205.7 (55.0) b
P, E Horizon (kg/ha)	0.0571	35.4 (29.0) a	19.3 (23.0) a	11.3 (6.1) a
Mg, Oi Layer (kg/ha)	0.2921	27.9 (43.8) a	11.3 (5.3) a	12.9 (2.9) a
SMP, Bs Horizon (kg/ha)	0.2998	64.5 (1.4) a	64.2 (0.9) a	65.1 (1.5) a
pH, C Horizon	0.0375	5.1 (1.2) a	5.1 (1.9) a	5.2 (1.4) a
P, C Horizon (ppm)	0.0268	34.3 (13.3) a	55.8 (28.3) ab	64.0 (27.0) b
OM, E Horizon (t/ha)	0.1546	24.9 (18.4) a	14.2 (7.3) a	18.2 (6.5) a
K, Oa Layer (kg/ha)	0.0188	65.2 (15.1) ab	72.8 (14.5) a	53.9 (11.8) b

[1] Means within a row followed by the same letter are not significantly different at the 0.05 level using the Scheffe test.

and have been widely used in developing a habitat type system for use in northern Michigan and Wisconsin (Coffman and Hall 1976, Kotar 1986). The percent frequency of the important discriminating species (Table 7) indicate that *Gaultheria procumbens* L., *Vaccinium angustifolium* Ait., *Corylus cornuta* Marsh., and *Waldsteinia fragarioides* (Michx.) Tratt. are all strong discriminators of the Vilas site unit. The more productive Padus site is discriminated by *Polygonatum biforum* (Walt.) Ell. and *Dryopteris spinulosa* (O.F. Mull.) Watt. The Pence site unit is generally intermediate; however, *Prenanthes alba* L., *Clematis virginiana* L., and *Lycopodium lucidulum* Michx. were found only on the Pence site units. Of these indicator species, only *Vaccinium* was identified by Pregitzer and Barnes (1982) as being a key indicator on the McCormick Experimental Forest in Upper Michigan. The jackknife validation procedure resulted in an overall 57% correct classification, with 60% of the Padus site units correctly classified, 10% of the Pence units correctly classified, and 100% of the Vilas units correctly classified.

The combined soil and vegetative discriminator variables are presented in Table 8. Combining these variables increased the classification percentage to 83, with 90% of the Padus units, 70% of the Pence units, and 90% of the Vilas units correctly classified. The soil and forest floor variables generally reflect the finer textures and higher nutrient content of the Padus and Pence site units, and the higher organic matter content of the Padus units. The vegetative species differ

Table 7. Means, standard deviations (in parentheses), and F statistics for vegetation discriminator variables presented in order of stepwise inclusion for the Padus, Pence, and Vilas site units in northeastern Wisconsin.

Variable (% Frequency)	*F Prob.*	*Padus*	*Pence*	*Vilas*
Gaultheria procumbens L.	0.0000	0.8 (2.6) a[1]	18.3 (24.2) a	70.0 (9.2) b
Vaccinium angustifolium Ait.	0.0000	5.0 (10.5) a	25.0 (25.5) a	65.0 (29.1) b
Lycopodium obscurum L.	0.3742	45.0 (42.7) a	36.7 (40.3) a	21.7 (25.8) a
Polygonatum biforum (Walt.) Ell.	0.0137	16.7 (18.0) a	1.7 (3.5) b	3.3 (8.1) ab
Aster macrophyllus L.	0.2424	80.0 (15.3) a	75.8 (22.4) a	59.2 (41.3) a
Prenanthes alba L.	0.1248	0.0 (0.0) a	1.7 (3.5) a	0.0 (0.0) a
Corylus cornuta Marsh.	0.0976	40.8 (25.3) a	35.0 (29.1) a	61.7 (28.9) a
Dryopteris spinulosa (O.F. Mull.) Watt.	0.2998	2.4 (5.6) a	0.8 (2.6) a	0.0 (0.0) a
Coptis trifolia (L.) Salisb.	0.4046	2.5 (7.9) a	3.3 (5.8) a	0.0 (0.0) a
Fragaria virginiana Duchesne.	0.1553	13.3 (15.3) a	25.0 (25.1) a	8.3 (15.2) a
Streptopus roseus Michx.	0.8473	1.7 (5.3) a	0.8 (2.6) a	0.8 (2.6) a
Waldsteinia fragarioides (Michx.) Tratt.	0.0103	0.8 (2.6) a	18.3 (38.7) ab	51.7 (46.6) b
Antennaria neglecta Grenne.	0.3811	0.0 (0.0) a	0.0 (0.0) a	0.8 (2.6) a
Clematis virginiana L.	0.3811	0.0 (0.0) a	0.8 (2.6) a	0.0 (0.0) a
Actaea alba (L.) Mill.	0.3811	0.8 (2.6) a	0.0 (0.0) a	0.0 (0.0) a
Linnaea borealis L.	0.1979	1.7 (5.3) a	10.8 (21.2) a	15.8 (20.6) a
Woodland grass	0.2844	90.0 (15.6) a	88.3 (27.6) a	75.8 (19.0) a
Lycopodium lucidulum Michx.	0.3811	0.0 (0.0) a	2.5 (7.9) a	0.0 (0.0) a
Rubus spp.	0.4179	16.7 (24.2) a	32.5 (28.5) a	31.7 (35.3) a
Myrica asplenifolia L.	0.0777	0.0 (0.0) a	0.0 (0.0) a	8.3 (15.7) a
Pyrola virens Schweigg.	0.6120	0.8 (2.6) a	0.8 (2.6) a	0.0 (0.0) a

[1] Means within a row followed by the same letter are not significantly different at the 0.05 level using the Scheffe test.

somewhat from those of Table 7. *Melampyrum lineare* Desr. and *Antennaria neglecta* Grenne. emerged as good discriminators for the Vilas units and *Viola* spp. for the Padus site units.

Conclusion

The development of usable forest site classification systems for large land ownerships is an important area of research. Multiple factor systems based on landform and climate, soils, and vegetation appear to be emerging as superior to the traditional single-factor approaches such as the soil survey. The usefulness of understory vegetative indicators to account for soil differences (Carleton et al. 1985, Pregitzer and Barnes 1982) makes those systems based on ground vegetation desirable. For forestry purposes it is also important that the defined units in the classification system be distinct in terms of site productivity and management interpretations.

In this study three site units from a two-county area in northeastern Wisconsin were subjected to a discriminant analysis based on groups of independent soil and vegetation variables. The strongest analysis, based on 11 soil and 12 vegetative variables, resulted in an overall correct classification of 83%. The Padus, Pence, and Vilas site units are distinct entities, separable in the field based upon soil and vegetative features, and have important soil physical and chemical property differences that readily separate the units when subjected to a stepwise discriminant analysis.

Table 8. Means, standard deviations (in parentheses), and F statistics for site, soil, and vegetation discriminator variables presented in order of stepwise inclusion for the Padus, Pence, and Vilas site units in northeastern Wisconsin.

Variable	F Prob.	Padus	Pence	Vilas
Red Pine				
Site Index (m)	0.0000	18.4 (0.9) a[1]	16.7 (0.4) b	16.5 (0.4) b
% Clay, E Horizon	0.0043	8.2 (2.8) a	6.3 (1.1) ab	5.2 (1.0) b
Viola spp.	0.0007	42.5 (19.4) a	36.7 (24.0) a	5.8 (15.7) b
K, Oi Layer (kg/ha)	0.3422	14.0 (4.3) a	11.7 (3.3) a	12.9 (3.0) a
Lonicera canadensis Marsh.	0.2233	1.7 (3.5) a	7.5 (10.7) a	4.2 (5.9) a
K, Oa Layer (kg/ha)	0.0188	64.2 (15.1) ab	72.8 (14.5) a	53.9 (11.8) b
pH, Bhs Horizon	0.0016	5.1 (0.1) a	4.8 (0.2) b	4.9 (0.1) b
Antennaria neglecta Grenne.	0.3811	0.0 (0.0) a	0.0 (0.0) a	0.8 (2.6) a
Corylus cornuta Marsh.	0.0976	40.8 (25.3) a	35.0 (29.1) a	61.7 (28.9) a
Lycopodium obscurum L.	0.3742	45.0 (42.7) a	36.7 (40.3) a	21.7 (24.8) a
Polygonatum biforum (Walt.) Ell.	0.0137	16.7 (18.0) a	1.7 (3.5) b	3.3 (8.1) ab
Depth, Bs Horizon (cm)	0.0063	35.8 (12.0) a	25.4 (9.2) ab	20.9 (7.5) a
Diervilla lonicera Mill.	0.1872	3.3 (7.0) a	18.3 (21.8) a	17.5 (25.9) a
Cornus canadensis L.	0.1781	11.7 (20.9) a	40.0 (37.2) a	28.3 (38.5) a
K, Bhs Horizon (kg/ha)	0.2341	88.7 (47.3) a	92.9 (63.5) a	58.9 (21.7) a
Apocynum androsaemifolium L.	0.0606	0.0 (0.0) a	0.0 (0.0) a	5.0 (9.0) a
Streptopus roseus Michx.	0.8473	1.7 (5.3) a	0.8 (2.6) a	0.8 (2.6) a
OM, E Horizon (t/ha)	0.1546	24.9 (18.4) a	14.2 (7.3) a	18.2 (6.5) a
pH, C Horizon	0.0375	5.1 (0.1) a	5.1 (0.2) a	5.2 (0.1) a
Adiantum pedatum L.	0.3811	0.8 (2.6) a	0.0 (0.0) a	0.0 (0.0) a
OM, Bs Horizon (t/ha)	0.0239	52.2 (14.0) a	44.9 (16.9) ab	33.1 (12.7) b
% Silt, C Horizon	0.2431	9.9 (5.7) a	8.4 (6.3) a	5.6 (5.1) a
Melampyrum lineare Desr.	0.2456	0.0 (0.0) a	0.8 (2.6) a	11.7 (29.2) a

[1] Means within a row followed by the same letter are not significantly different at the 0.05 level using the Scheffe test.

Of the 23 discriminating variables listed in Table 8, 11 are soil or site variables, and 12 are vegetative variables. Calculated site index, an integrated site variable, was the most significant. Soil variables that were important included physical properties such as depth and texture, and chemical properties such as fertility (potassium content), organic matter content, and pH. Important vegetative discriminators included *Viola* spp., *Polygonatum biforum, Corylus cornuta,* and *Apocynum androsaemifolium.*

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