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THE MINK RIVER — A FRESHWATER ESTUARY

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Abstract

The Mink River Estuary is one of the few remaining natural wetlands along the Lake Michigan coastal zone. The river flows through a bedrock valley across the Door Co., Wisconsin, peninsula. Surficial materials forming its watershed are glacial and post-glacial, mainly shoreline material placed during higher levels of Lake Michigan.

The dynamics of Lake Michigan play an important role in the control of wetland plant communities. Most expand and contract as the lake level falls and rises over the long-term. Lake seiches cause the water in the wetlands to flow upstream and downstream in both a daily and hourly cycle, generating a persistent gradient between the alkaline headwater springs and more neutral lake.

Land use adjacent to the river has changed little since presettlement, although the upland forest in the surrounding watershed has been largely replaced by farm fields. The estuary consists of several vegetation types. The deep marsh and shallow marsh types are inhabited by communities of few species, owing to disturbance by long-term changes in lake water level. The wet meadow, shrub carr, and lowland forest types are more diverse, largely because they are more protected from extreme water level change by elevation and, in the case of wet meadow species, by the development of hummocks by *Carex stricta*. Peak above- and below-ground biomass found in herbaceous wetland communities in 1981 are presented. Perennial species peak in August, while annuals peak in September; most below-ground accumulation peaks in September.

INTRODUCTION

The U.S. shoreline of the Great Lakes is nearly 4000 miles in length. Wetlands occupy only a small proportion of the coastal region; 1370 coastal wetlands, comprising an area of 466 square miles, have been identified (Herdendorf et al. 1981). Approximately 30% of U.S. Great Lake wetlands occur adjacent to Lake Michigan. Many rivers that flow into the Great Lakes were once associated with wetland areas; most of these are now either heavily disturbed or have been destroyed by urban development. Curtis did not recognize Great Lakes coastal wetlands as a community type in his *Vegetation of Wisconsin* (1959). In recent years, there have been a number of descriptive studies of wetlands along the Lower Great Lakes (Williamson 1979, Brant and Herdendorf 1972, Fahselt 1981, Hanink 1979, Herdendorf et al. 1981, Jaworski and Raphael 1976, Mudroch 1981, Geis, 1985, Geis and Kee 1977, Stuckey 1971, 1975, LeMay and Mulamoottil 1980, Farney and Bookhout 1982, and Ruta 1981). The few studies of Wisconsin coastal wetlands deal primarily with those along Green Bay (Bosley 1976, 1978, Harris et al. 1977, Howlett 1974, and Roznik 1978).

The Mink River supports one of the best of the remaining Lake Michigan coastal wetlands. Located near the tip of the Wisconsin Door County Peninsula, the Mink River flows southeastward into

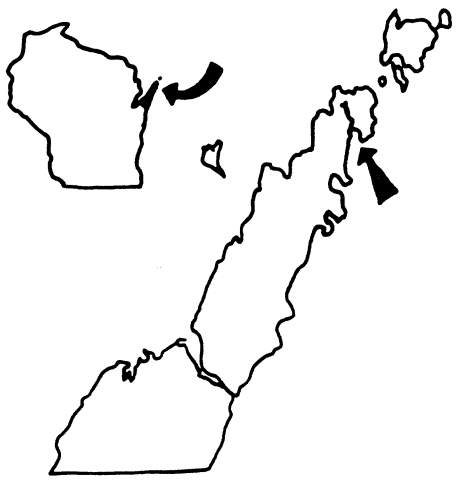

Fig. 1. Location of the Mink River on the Door County, Wisconsin, peninsula.

Rowley Bay of Lake Michigan (Figure 1). The watershed lies in Liberty Grove Township (T32N, R28 and 29E). In this paper, I will describe the physical setting of the Mink River wetlands and the vegetation types present and their dynamic relationship with Lake Michigan.

Topography and Geology

Rowley Bay and the Mink River lie in a bedrock valley that extends across the Door peninsula from Green Bay to Lake Michigan (Kowalke 1946). During the Algonquin period, when the level of Lake Michigan was higher, the valley formed a strait connecting Green Bay to Lake Michigan from Ellison Bay to Rowley Bay. The underlying bedrock is Silurian Niagara dolomite; as elsewhere in the Door Peninsula, this formation dips to the southeast, and forms the primary aquifer. A wide portion of the river, "Rogers Lake," may represent a natural depression in the bedrock or an area eroded by the channel before descending into Lake Michigan. Bedrock is within four feet of the surface near Ellison Bay and outcrops in the upland around the Mink River. The upland is covered by Pleistocene drift and shoreline deposits. Most of the region was inundated by post-Pleistocene stages of Lake Michigan, resulting in permeable deposits of sand and gravel along the west side of the river (Sherrill 1978). Thwaites and Bertrand (1957) and Kowalke (1946) suggested that the uplands to the northeast and southwest of the river were islands in Lake Algonquin, a higher stage of Lake Michigan. A shoreline formed by Glacial Lake Algonquin (11,000-12,000 yr BP) has been found along Rowley Bay in Newport State Park at approximately 75 feet above present lake level. A Glacial Lake Nipissing shoreline (3,500-6,000 yr BP) occurs 21 feet above present level (Frelich 1979, Dorr and Eschmann 1977). The ancient beach ridges evident in the landscape around Rowley Bay were Lake Nipissing beaches. The marsh along the Mink River is underlain by alluvial fine sand, silt and clay and organic material.

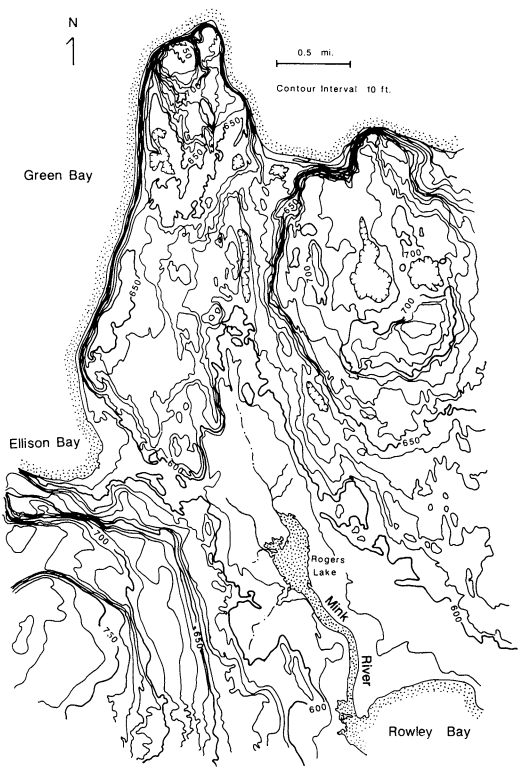

Fig. 2. Topography of the area surrounding the Mink River. Contour interval is 10 feet. Stippled areas represent open water and lakeshore boundaries.

These fine grey sediments and the sandy soils of the surrounding area were probably deposited during this post-glacial lake stage. Declining lake level and land rebound have raised the old beaches and also separated the Mink River watershed from Green Bay (Figure 2).

Hydrology

Hydrologic aspects of the watershed are the most important factors contributing to the character of the Mink River wetland. There are three primary sources of water: precipitation, groundwater springs, and Lake Michigan. Surface runoff from the small watershed is limited by lowland forest vegetation.

Springs located in the lowland forest surrounding the marsh discharge into the wetland creeks throughout the year. Springs also emerge within the wetland; these have been observed as open pools in February surrounded by the snow-covered marsh. Weathered limestone is exposed at the bottom of the headwater springs, attesting to their origin in the bedrock aquifer.

The channels connecting the headwater springs to the river appear well entrenched in the substrate. A review of past aerial photographs (1938, 1952, 1962, 1967, 1974, 1978) indicates that location of the channels has not changed appreciably in almost 50 years. Sherrill (1978) suggested that the drift overlying the bedrock around and under the Mink River is shallow. The main channel of the Mink River forms a distinct and apparently unchanging bend as it flows near an upland bedrock knoll. Although most of the depression containing the river and wetland appears to have been filled by lake sediments and beach deposits, the channel forms suggest bedrock control of the major channels.

Rainfall is moderate; the NOAA station on nearby Washington Island records an average annual precipitation of 29 inches. Approximately half of this amount falls during the growing season.

Precipitation and spring flow vary little from year to year. However, Lake Michigan plays a dominant role in wetland dynamics. The level of the lake has varied widely in historic time (Figure 3). Aerial photographs

Fig. 3. Mean annual level of Lake Michigan, 1935-1981 (from N.O.A.A. 1981).

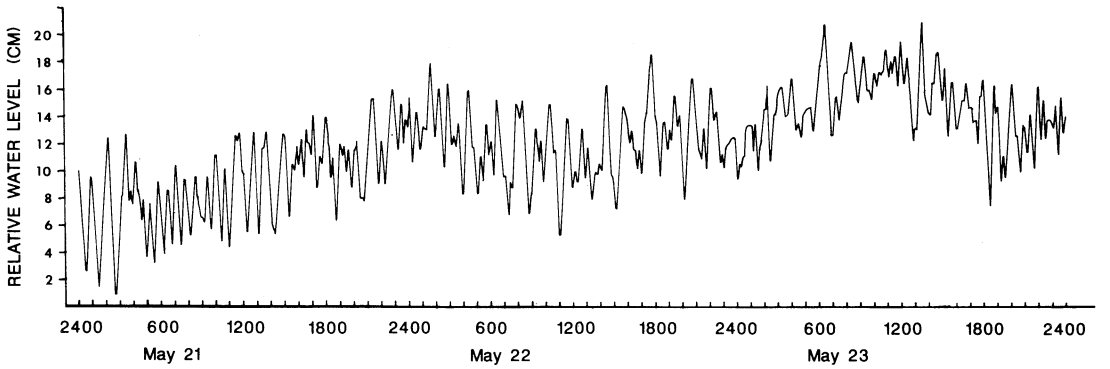

Fig. 4. Measurement of water level fluctuation in one of the headwater creeks, approximately 100 meters from a bedrock spring, taken between May 21-23, 1983. While the amplitude varies, the period is constant throughout the ice-free season.

taken since 1938 show that during periods of high lake levels, the open water area of the river and marsh increased along the entire length of the river. In alternating periods when the lake level was low, the wetland communities expanded into the open water.

Seiche activity originating in the lake results in water moving upstream and then downstream daily; superimposed is another mode in which water moves up and down the river in approximately an hourly cycle. An example of seiche activity is shown in Figure 4; this measurement was made with a water level recorder located upstream of Rogers Lake in one of the headwater creeks. Fluctuations at the mouth of the River are typically between 10 an 30 cm in magnitude, and occasionally much larger following high winds. Both seiche modes cause the water to rise and fall throughout the wetland, throughout the ice-free season. This results in mixing between the highly alkaline water discharging from the headwater springs and the water from Lake Michigan that is driven upstream. Water samples have been collected during all ice-free seasons; an example of the chemical gradient found along the length of the Mink River is illustrated in Figure 5. Specific conductance and alkalinity range from 475 to 275 mmhos/cm and 260 to 110 mg/1 respectively; this pattern is maintained from the time of ice-melt in spring through the time when the bay and river surfaces freeze in winter. Based on these seiche movements and the chemical gradient, the Mink River may be considered a true estuary.

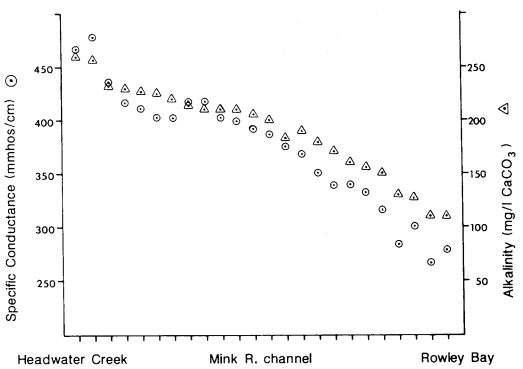

Fig. 5. Evidence of a chemical gradient along the Mink River channel. The X-axis is a series of sample stations along the length of the river, from a headwater spring and creek (left) through the river channel (center) to Rowley Bay (right). Specific conductance and alkalinity both decrease along the river.

Land Use

The Door Peninsula has had a relatively long history of human activity. Initially, Indian tribes moving up and down the lakeshore probably used the area around the Mink River for encampments. There was a more permanent village on the south side of the bay, but it is not clear whether this was a Winnebago or Potawotami tribe. Logging removed most of the upland forest cover during the late 1800's. White cedar in the lowland forest was also harvested for both lumber and cedar oil; an oil-distilling factory was located near Rowley Bay. There was

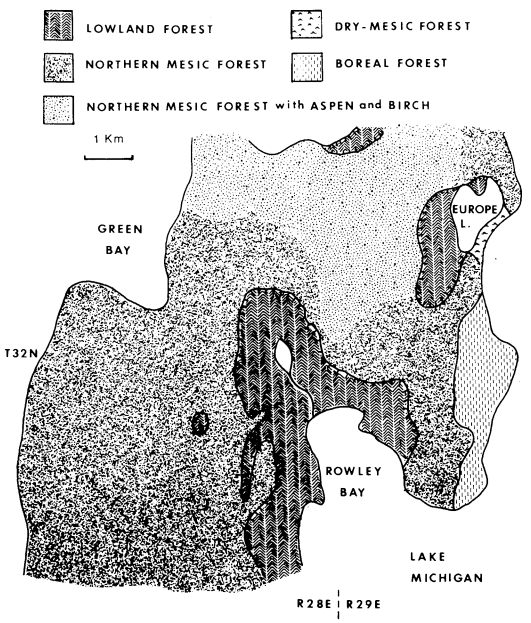

Fig. 6. A map of the presettlement forest in the area of the Mink River (derived from Findley, 1976 and personal communication). Emergent marsh is not mapped. Vegetation types follow Curtis (1959).

considerable land speculation during this period as well; much of the Mink River basin was platted and some lots sold, although no development occurred. Farms were cleared in portions of the Mink River watershed, as everywhere in the Door Peninsula (Holand, 1959). Thus, the Mink River wetland is not surrounded by a pristine landscape; yet, for the most part, the vegetation surrounding the wetland and river is similar to that before settlement. The township including the Mink River was surveyed in 1835. A map of the forest vegetation has been derived from Findley (1976 and personal comm) and from the General Land Office Survey Notes (Figure 6). Although most of the upland forest has been replaced by open fields and orchards, a northern wet forest, dominated by white cedar and tamarack with some black ash, still borders the river (Figure 7).

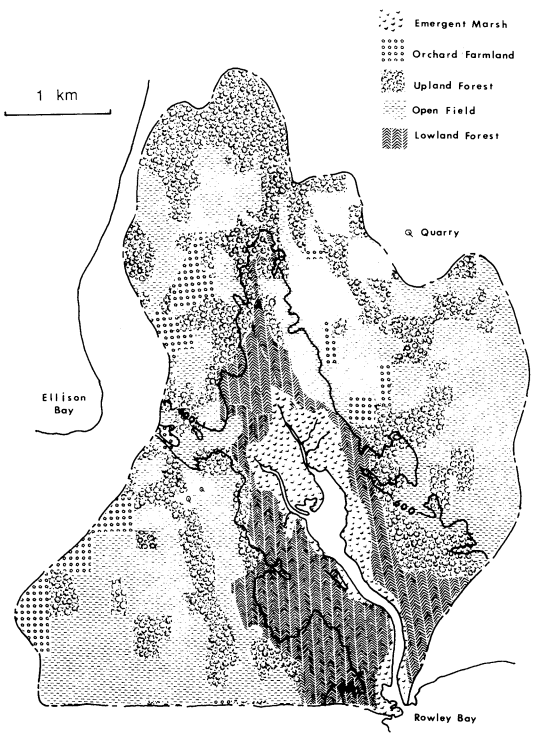

Fig. 7. A map of present land use in the Mink River watershed; note that the areas adjacent to Ellison Bay and Green Bay are not included here.

An excellent northern mesic forest stand occupies the land just north of Rowley Bay.

Present Vegetation

The emergent marsh along the Mink River is the most dynamic feature of the watershed vegetation. Lake level controls the succession of wetland communities along the Mink River. The marsh has contracted and expanded as Lake Michigan has risen and fallen. The plant communities present at a given time are the result of the opposing forces of community development and of disturbance. The extent of dominant communities in 1981 is illustrated in Figure 8.

During the 1980 and 1981 growing seasons, the emergent communities were

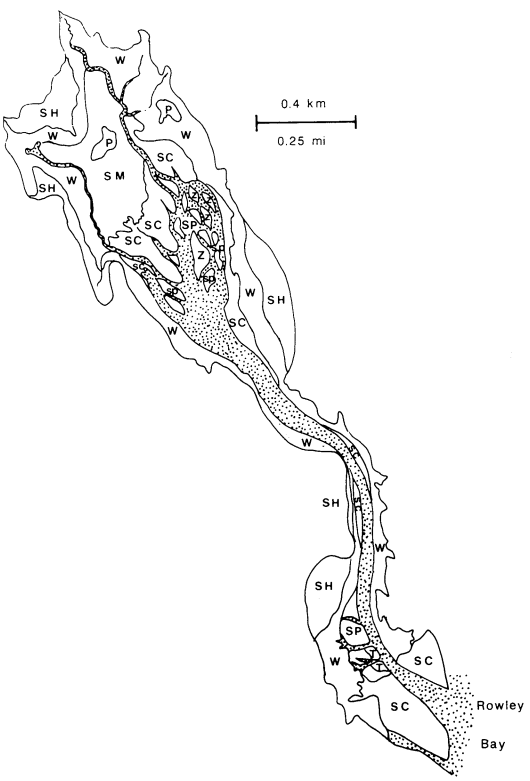

Fig. 8. A map of the vegetation of the Mink River estuary, as found in 1981-1982. Vegetation types are: SH, shrub carr; W, wet meadow; shallow marsh dominated by *Carex* (SM) and *Phragmites* (P); deep marsh dominated by *Scirpus* (SC), *Zizania* (Z), *Sparganium* (SP), and *Typha* (T).

TABLE 1. Plant species found in Mink River vegetation communities. Nomenclature follows Gleason and Cronquist (1963).

	Deep Marsh	*Shall. Marsh*	*Wet Meadow*	*Shrub Carr*	*Lowl. Forest*
Betula papyrifera Marsh.					X
Fraxinus nigra Marsh.					X
Abies balsamea Mill.					X
Tsuga canadensis Carr.					X
Populus deltoides Marsh.					X
Thuja occidentalis L.				X	X
Acer spicatum Lam.				X	X
Larix laricina K. Koch.				X	X
Alnus rugosa Spreng.				X	X
Cornus stolonifera Michx.			X	X	
Salix spp.			X	X	
Spiraea alba DuRoi.			X	X	
Calamagrostis canadensis Beauv.			X	X	
Iris virginica L.			X		
Eupatorium maculatum L.			X		
Campanula aparinoides Pursh.			X		
Gerardia purpurea L.			X		
Lobelia kalmii L.			X		
Chelone glabra L.			X		
Juncus effusus L.			X		
Acorus calamus L.			X		
Carex stricta Lam.			X	X	
C. hystericina Muhl.			X	X	
C. diandra Schrank.			X	X	
C. lacustris Willd.			X	X	
C. rostrata Stokes.			X	X	
C. aquatilis Wahl.		X	X		
C. prairea Dewey.		X	X		
Phragmites australis (Cav.) Steudel.		X	X		
Typha latifolia L.		X	X		
T. angustifolia L.	X	X			
Sagittaria latifolia Willd.	X	X	X		
Scirpus atrovirens Willd.			X		
S. validus Vahl.	X	X			
S. acutus Muhl.	X				
S. americanus Pers.	X				
Eleocharis smallii Britton.	X				
Sparganium eurycarpum Engelm.	X				
S. chlorocarpum Rydb.	X				
Equisetum fluviatile L.	X				
Zizania aquatica L.	X				
Potamogeton pectinatus L.	X				
P. richardsonii Rydb.	X				
P. praelongus Wulfen.	X				
P. gramineus L.	X				
Myriophyllum spicatum L.	X				
Polygonum coccineum Muhl.	X				
Elodea canadensis Michx.	X				
Nuphar advena Ait.	X				
Nymphaea odorata Ait.	X				
Chara spp.	X				

sampled, and observations were made of submergent species (species are listed in Table 1). Estimates of biomass were made using samples of above- and below-ground material harvested in each community every month during the two growing seasons. Peak biomass values from that period are presented in Table 2, and each community is described below.

Deep Marsh

The deep marsh complex occurs adjacent to channels of the Mink River. Several species form this community type, but seldom do more than two or three occur together. For example, *Sparganium eurycarpum* forms monotypic stands near the river mouth and in patches on mud flats in "Rogers Lake." Occasionally, a few individuals of *Sagittaria latifolia* are intermixed with *Sparganium. Zizania aquatica* is found in monotypic stands on mudflats. *Zizania* populations fluctuate widely from year to year; dense populations are found only during years when mudflats are exposed or near the water surface. For example, in 1982, the level of Lake Michigan was 6 inches lower than in 1981. Mud flats were exposed in Rogers Lake, and supported more numerous and dense *Zizania* populations than the previous year.

Scirpus validus occurs over a wide range of water level conditions. This species forms monotypic stands on shallow organic mudflats around Rogers Lake. With *Sagittaria latifolia,* it forms two-species stands along the Mink River channel. A tall form, probably a hybrid with *S. acutus* (Galen Smith, pers. comm), grows with *Eleocharis smallii* around the edge of Rowley Bay. *Scirpus americanus* also forms monotypic stands in deep water in the open bay, where the populations are exposed to wind and waves. *Typha angustifolia* also forms single species

TABLE 2. Peak biomass of emergent herbaceous communities of the Mink River estuary in 1981. Month of peak biomass occurrence is indicated.

Community Type	*Above Ground g/m² (month)*	*Below Ground g/m² (month)*	*Areal Extent km²*
Deep Marsh			
Scirpus validus Community			
in Rowleys Bay	595.4 (Aug)	1373.6 (Aug)	0.474
along Mink R. channel	204.1 (Aug)	268.6 (Sept)	0.052
shallow marsh edge	194.9 (Aug)	336.6 (Sept)	0.285
edge of Rogers Lake	410.1 (Aug)	493.6 (Sept)	0.050
Sparganium eurycarpum Community			
at river mouth	512.7 (Aug)	704.0 (Sept)	0.120
Rogers Lake islands	628.2 (Aug)	400.3 (Aug)	0.100
Zizania aquatica Community			
Rogers Lake islands	545.5 (Sept)	207.7 (Sept)	0.073
Typha angustifolia Community			
at river mouth	880.6 (Aug)	1626.4 (Sept)	0.041
Shallow Marsh			
Carex aquatilis/C. prairea Community			
between headw. creeks	327.1 (Aug)	806.0 (Sept)	0.496
Phragmites communis Community			
between headw. creeks	686.1 (Sept)	1867.6 (Sept)	0.060
Wet Meadow			
Calamagrostis canadensis/Carex stricta Community			
along river	779.7 (Sept)	6486.8 (Sept)	1.968

stands along the Mink River channels and in Rogers Lake.

Shallow Marsh

This type includes two species associations. An even mixture of *Carex aquatilis* and *C. prairea* forms extensive meadows that fringe the spring-fed channels upstream. These are the only two species in most of the area; along the channel-marsh interface, they mingle with *Typha latifolia, Phragmites australis, Scirpus validus, Calamagrostis canadensis* and *Carex stricta. Phragmites australis* is found to be dominant in extensive clones within the area of the *Carex aquatilis-prairea* community. This species forms a complete canopy with individuals of the two *Carex* species as a sparce understory. *P. australis* is common in disturbed wetland sites in Wisconsin, but in the Mink River shallow marsh there is little evidence of human disturbance. However, *Phragmites* may have invaded the wetland after a disturbance, such as a fire during a dry period of low lake level. The reason for its continued persistence is not known.

Wet Meadow

A wet meadow community dominated by *Carex stricta* and *Calamagrostis canadensis* borders the entire marsh. This community is the most diverse wetland type around the Mink River and includes several carices and other forbs (Table 1). Some of these, including *Calamagrostis, Campanula aparinoides,* and *Lobelia kalmii,* are modal in fen communities in Wisconsin (Curtis, 1959). Wet meadow borders swamp forest and shrub carr, and is often invaded by woody species (*Salix* spp. *Cornus stolonifera, Thuja occidentalis, Spiraea alba*). Dead woody stems are frequently found, evidence of past invasion thwarted by periods of high water.

Review of early aerial photographs suggests that this community may be resistant to long-term fluctuations in water level. The co-dominants, *Calamagrostis canadensis* and *Carex stricta,* occupy tall (up to 50 cm) hummocks formed by the latter, often surrounded by shallow standing water. These hummocks may provide a habitat that is not appreciably affected by changes in water level, or may permit development of propagules over a wide range of elevations above water. Substrate cores were taken in all wetland populations. Except in cores from the wet meadow, all of the present plant communities were underlain by remains of different species. Sedge and grass roots and rhizomes were found within and under the hummocks, suggesting that, while other communities were shifting with time and environmental conditions, the wet meadow has been persistant. Pieces of wood were occasionally found in cores, indicating temporary invasion by trees and shrubs.

Shrub Carr

The interface between the marsh and the surrounding upland is inhabited by a mixture of small trees, shrubs, and herbaceous wetland species, forming a shrub carr community that expands and contracts with the changing lake level. Species such as *Cornus stolonifera, Spiraea alba, Alnus rugosa* and seedlings of *Thuja occidentalis, Larix laricina, Acer spicatum,* and *Salix* spp. invade the wet meadow during drier periods. Dead stems indicate the return of high water. This appears to be a temporary community, as long as occasional periods of high water conditions continue to occur. With a drastic long-term lowering of water level, this community would probably develop into lowland forest.

Lowland Forest

A lowland swamp community surrounds most of the Mink River marsh. *Thuja occidentalis* is dominant, but there are significant numbers of *Betula lutea* and *B. papyrifera, Fraxinus nigra, Larix laricina, Populus deltoides, Acer spicatum,* and *Abies balsamea.* The importance of each varies greatly and is probably dependent on stand history and hydrology. This lowland forest has been

disturbed by logging and by natural events. The latter are evidenced by much wind throw and root upheaval, resulting from flooding, storms, and ice activity. This forest community has largely protected the river and wetland from human disturbance by virtue of the wet organic soil and dense vegetation.

Wetland Community Biomass

During the 1981 growing season, biomass samples were collected monthly from the major emergent vegetation types. These are presented as peak above-ground and below-ground biomass estimates (Table 2). Shrub carr, swamp forest, and *Scirpus americanus* communities were not sampled. Submergent vegetation also was not sampled because, in general, individuals occur in small patches amid emergent plants, and because representative sites could not be identified. The areal extent of each community is a highly dynamic parameter that will vary from year to year as the communities expand and contract in response to lake level changes. The extent of each of these communities was estimated in 1981 (Table 2).

Peak biomass alone is not adequate to represent relative vegetation importance, however. *Zizania aquatica* is an example of an annual plant in which a cohort of seeds develops simultaneously, all flowering and setting seed at roughly the same time. Perennial species, on the other hand, develop rhizomatous ramets continuously during the growing season; examples of these are *Eleocharis palustris, Scirpus validus,* and *Sparganium eurycarpum;* some of these, such as *Sparganium* and *Typha angustifolia,* exhibit synchronous flowering and seed set as well. Stem death may occur throughout the growing season; this is evident within the *Scirpus* populations upstream from Rowley Bay. Often, peak above-ground and below-ground biomass did not occur during the same month. Those populations that peaked in September also had seeds maturing at that time. In other communities, stems and leaves were senescent by September. Most rhizomatous species develop storage material and over-wintering buds in the fall. Nonetheless, measurements of peak biomass permit comparison between communities and provide estimates of the maximum amount of production available to the system food web.

The wet-meadow community produced the largest peak biomass and had the greatest areal extent. This is intriguing in light of the apparent stability of this association. Much litter is present throughout the year, suggesting that production does not immediately enter the food web, and that this is a zone of accumulation. The shallow marsh community also seems to accumulate litter. The above-ground biomass of deep water communities is lost over winter, presumably broken up and removed by ice action, spring runoff and high water. Rafts of *Scirpus* stems are found along the beaches in spring; however, the amount and distribution of annual dead biomass through the river and bay is not known. The fate of production from other deep marsh species, whether by decomposition or outflow, is also unknown.

Discussion

The Mink River estuary is one of only a few Lake Michigan coastal wetlands that have not been significantly influenced by human activity. As such, it provides an opportunity to learn how plant and animal communities and individual species adapt and function in the coastal zone. The Mink River estuary, like other coastal wetlands, is subjected to various degrees of natural disturbance—principally changes in water level, but also massive ice movement and wave and wind activity. The low diversity of most plant communities in Rowley Bay and along the Mink River suggests that this site may be subject to more than average disturbance. The deep water communities experience the largest long-term changes in water level, as well as substantial wave action. Natural disturbance is sufficiently intense and frequent that there is not enough time for the development of diverse communities.

More protected communities, such as the wet meadow around the edge of the wetland, are more species-rich. The wet meadow community develops on and around *Carex stricta* hummocks; this topographic diversity, located higher in the watershed, permits the establishment of more species. Keddy and Reznicek (1985) suggested that the zonation of communities may be related to the position of maximum and minimum high water. They suggest that certain communities—wet meadow and shallow marsh—depend upon periodically exposed substrate for seed establishment. This appears to be so in the Mink River system; only those species that can survive by reproducing vegetatively persist in deep water. *Zizania aquatica* requires mudflat conditions in spring to germinate. Woody species on the shrub carr do not establish on hummocks, but in the low spots on the wet meadow. They are repeatedly killed by high water. Regeneration of such communities seems to be in phase with the cycle of low water conditions in Lake Michigan.

Little is known about the food web associated with Lake Michigan coastal wetlands. Harris et al. (1977) and Roznik (1978) have suggested that certain birds may respond to the dynamic structure of these emergent plant communities as water level changes from year to year. Furthermore, little is known about how the chemical gradient along the river may influence the distribution of aquatic plants or animals. Many intriguing questions can be raised concerning long-term fluctuations in biomass production by the various plant communities, as well as the fate of biomass and its contribution to the food web of the river and bay. Much can be learned about the adaptations of organisms in such a frequently disturbed coastal environment. Examples include the adaptations to long-term water level fluctuations by *Carex stricta* and *Calamagrostis canadensis,* by species of *Scirpus* (*S. americanum, S. acutus,* and *S. validus*), and by *Zizania aquatica.* While some coastal wetlands have been protected as natural reserves and are recognized as including unusual species associations or unique habitats, many biological and physical dynamics are still waiting to be explored.

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References Cited

Bosley, T. R. 1976. Green Bay's west shore coastal wetlands: a history of change. M.S. Thesis. University of Wisconsin-Green Bay. 92 pp.

Bosley, T. R. 1978. Loss of wetlands on the west shore of Green Bay. Trans. Wis. Acad. Sci., Arts and Lett. 66:235-245.

Brant, R. A. and C. E. Herdendorf. 1972. Delineation of Great Lakes estuaries. *In* Proc. 15th Conf. Great Lakes Research., I. A. G. L. R., Ann Arbor, MI. pp. 710-718.

Curtis, J. T. 1959. Vegetation of Wisconsin. University of Wisconsin Press, Madison, WI. 657 pp.

Dorr, J. A. Jr. and D. F. Eschman. 1977. Geology of Michigan. University of Michigan Press, Ann Arbor. 475 pp.

Fahselt, D. and M. A. Maun. 1980. A quan-

titative study of the shoreline marsh communities along Lake Huron in Ontario. Can. J. Plant Sci. 60:669-678.

Farney, R. A. and T. A. Bookhout. 1982. Vegetation changes in a Lake Erie marsh (Winous Point, Ottawa County, Ohio) during high water years. Ohio Acad. Sci. 82:103-107.

Frelich, F. T. 1979. Vascular plants of Newport State Park, Wisconsin. Wisconsin Dept. Natural Resources, Research Report No. 100. Madison, WI. 34 pp.

Findley, R. W. 1976. Original vegetation cover of Wisconsin. Map. USDA Forest Service, North Central Experiment Station, St. Paul, MN. 1 p.

Geis, J. W. 1985. Environmental influences on the distribution and composition of wetlands in the Great Lakes basin. *In* Prince, H. and F. M. D'Itri, Eds. Coastal Wetlands. Lewis Publ., Chelsea, MI. pp 15-32.

Geis, J. W. and J. L. Kee. 1977. Coastal wetlands along Lake Ontario and St. Lawrence River in Jefferson County, New York. State Univ. of New York, Inst. of Environmental Program Affairs, Syracuse, N.Y. 130 pp.

Gleason, H. A. and A. Cronquist. 1963. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Van Nostrand Co., New York. 810 pp.

Hanick, M. S. 1979. Wetland loss and coastal land use changes in Monroe Co., Michigan. 1912-1975. MS Thesis. Eastern Michigan University, Ypsilanti, MI. 118 pp.

Harris, H. J., T. R. Bosley, and F. D. Roznik. 1977. Green Bay's coastal wetlands—a picture of dynamic change. *In* DeWitt, C. B. and E. Soloway, Eds. Wetlands. Ecology, Values, and Impacts. Proceedings Waubesa Conference, Madison, WI. pp 337-358.

Herdendorf, C. E., S. M. Hartley, and M. D. Barnes. 1981. Fish and wildlife resources of the Great Lakes coastal wetlands within the United States. Vol. I. Overview. Report No. FWS/OBS-81/o2-V1. U.S. Fish and Wildlife Service. Washington, D.C. 469 pp.

Holand, H. 1959. Old Peninsula Days. Twayne Publishers, New York. 425 pp.

Howlett, G. F. 1974. The rooted vegetation of West Green Bay with reference to environmental change. MS Thesis. Syracuse Univ., Syracuse, N.Y. 213 pp.

Jaworski, E. and C. N. Raphael. 1976. Modification of coastal wetlands in southeastern Michigan and management alternatives. Michigan Academician 8(3):303-317.

Keddy, P. A. and A. A. Reznicek. 1985. Vegetation dynamics, buried seeds, and water level fluctuations on the shorelines of the Great Lakes. *In* Prince, H. and F. M. D'Itri, Eds. Coastal Wetlands. Lewis Publ. pp 33-58.

Kowalke, O. L. 1946. Highest abandoned beach ridges in northern Door County, Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 38:293-298.

LeMay, M. and G. Mulamoottil. 1980. A limnological survey of eight waterfront marshes. Urban Ecology 5:55-67.

Mudroch, A. 1981. A study of selected Great Lakes coastal marshes. Scientific Series #122. Nat. Water Res. Inst., Inland Waters Directorate, Burlington, Ontario. 44 pp.

N.O.A.A. 1981. Hydrograph of monthly mean levels of the Great Lakes. U.S. Dept. Commerce, Washington, D.C. 1 p.

Roznik, F. D. 1978. Response of the yellow-headed blackbird to vegetation and water level changes in the coastal marshes of Green Bay. MS Thesis. Univ. Wisconsin-Green Bay. 99 pp.

Ruta, P. J. 1981. Littoral macrophyte communities of the St. Lawrence River, New York. MS Thesis. SUNY College Environ. Sci. For., Syracuse, NY. 153 pp.

Sherrill, M. G. 1978. Geology and groundwater in Door County, Wisconsin, with emphasis on contamination potentials in the Silurian dolomite. Water Supply Paper 2047. U.S. Geol. Survey and Wisconsin Dept. Nat. Resources, Madison, WI. 38 pp.

Stuckey, R. L. 1971. Changes of vascular aquatic plants during 70 years in Put-In-Bay Harbor, Lake Erie, Ohio. Ohio J. Science. 71:321-342.

Stuckey, R. L. 1975. A floristic analysis of the vascular plants of a marsh at Perry's Victory Monument, Lake Erie. Michigan Botanist 14: 144-166.

Thwaites, F. T. and K. Bertrand. 1957. Pleistocene geology of the Door Peninsula, Wisconsin. Geol. Soc. Amer. Bull. 68:831-880.

Williamson, B. B. 1979. The wetlands of Dickinson Island, St. Clair Co., Michigan and its response to water level fluctuations. MS Thesis, Eastern Michigan University, Ypsilanti, MI. 96 pp.

PLEISTOCENE CARIBOU IN CENTRAL WISCONSIN

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In the summer of 1985, Jack and Mona Zelienka found an antler while excavating their peat bog 6 miles southeast of Coloma, on County JJ in the township of Richford, Waushara County, Wisconsin. The antler was stained and heavy with mineral replacement, obviously of great age, broken at all distal aspects (during excavation), and was shed from a Late Pleistocene caribou (*Rangifer tarandus*). The bog, which had been previously excavated 10 to 12 feet in some places to create a pond, was deepened to nearly 30 feet. Subsequently the antler was discovered in the excavated sediments of marl and peat; its depth in the peat was estimated at between 12 and 25 feet. The bog is sited near the proposed Ice Age Trail along the Wisconsin terminal moraine in Cary drift. This is the first record of the caribou from central Wisconsin, and one of but a few for the state.

The antler (all in one piece) consists of a brow tine (or "shovel") with tip broken away (length 153 mm); a main beam approx-

Fig. 1. Antler of caribou excavated from peat in Richford Township, Waushara County, Wisconsin.

imately 625 mm measured to the terminal palmate expansion, broken off and hollow; from the burr about 150 mm to the base of the first palmate tine; and along the beam 260 mm beyond to the next and opposite tine (entirely broken away). The length from tip of brow tine to the broken expansion is approximately 700 mm. The first palmate tine on the main beam measured 350 mm from the beam to the deepest notch of the palm, which was 205 mm across. Its greatest length was 392 mm. The diameter of the ovate base, shed from the pedicel, is about 42 to 47.5 mm in diameter, and of the burr approximately 61.5 mm (see Fig. 1).

Never common in Wisconsin and Upper Michigan in historic times, caribou wandered into these areas from muskeg habitats in nearby Minnesota and Ontario. A. W. Schorger (1942) reviewed the records and reports of caribou, listing several from the Upper Peninsula of Michigan and questionable ones for the Brule area in northwest Wisconsin, probably escaped animals from the Pierce estate. Among prehistoric bones found in Polk County, also northwest Wisconsin, a few were reported as caribou (Eddy and Jenks, 1935).

The caribou apparently wandered into lower Michigan after the Wisconsin glacier receded. Specimens were dated at 11,200 and 5,870±200 years BP. Baker (1983) suggests that historical records represent the woodland caribou, whereas the prehistoric caribou were of a larger Arctic form (but the woodland caribou is a large form). Subspecific characters are hardly obvious in broken and fragmentary remains of antlers. Even the sex is impossible to know. Banfield (1974) and other Canadian workers considered all the large woodland caribou to belong to one subspecies, *R. t. caribou.* Apparently all the caribou in Wisconsin belonged to this species and descended from the same stock.

The antler herein described is slightly smaller but very similar in form to that figured by West (1978) from southeast Wisconsin. The nearest of his records is approximately 150 km southeastward, in Sheboygan County. The other is from Wauwatosa, near Milwaukee.

West (1978) assigned his specimens to Late Pleistocene age, one antler dated by its sediments to about 12,500 years BP. In summary, all known prehistoric caribou from Wisconsin are scattered along the front of the Wisconsinan moraines in Polk, Waushara and Sheboygan counties, and near Milwaukee. I acknowledge with thanks the cooperation of both of the Zelienkas.

Literature Cited

Baker, R. H. 1983. Michigan mammals. Michigan State Univ. Press and Wayne State Press, Detroit, Michigan. 642 pp., illus.

Banfield, A. W. F. 1974. The mammals of Canada. Univ. Toronto Press, Toronto. 438 pp.

Eddy, S. and A. E. Jenks. 1935. A kitchen midden with bones of extinct animals in the Upper Lakes area. Science, 81(2109):535.

Schorger, A. W. 1942. Extinct and endangered mammals and birds of the Upper Great Lakes Region. Trans. Wis. Acad. Sci., Arts and Lett. 34:23-44.

West, R. M. 1978. Late Pleistocene (Wisconsinan) caribou from southeastern Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 66: 50-53.

TECHNOLOGY, INSTITUTIONS, GLOBAL ECONOMY AND WORLD PEACE

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It seems quite natural for creative human beings to invent or modify techniques for satisfying their changing needs and wants. In this process and over time, the concept of what constitutes a natural resource changes with changing human aims, objectives and ambitions. What constitutes a resource in human terms is indeed a function of knowledge and technique. Only a little more than a century ago petroleum near the surface was considered a nuisance; today it is referred to as black gold. The moon was a romantic symbol and outer space a void throughout most of history; today both are becoming highly prized resources. The changing view of resources brought about by new knowledge, new techniques and new wants often leads to conflict. New or modified human institutions are required to manage these conflicts and to keep them from destroying the community.

Changing techniques and scientifically advanced technologies, like new resources, often require a redefinition of the political unit that makes public policy. In the more or less self-sufficient Wisconsin farming communities of 100 years ago, where the major source of power and transport was the horse, local communities could set the rules. But with the coming of the automobile, a hodgepodge of local rules and regulations proved chaotic. The building of roads, the registration and licensing of both vehicles and drivers, the handling and sale of gasoline, the responsible and safe use of these powerful "horse-less carriages," etc., required a new set of institutions and a larger political unit to make public rules. The State of Wisconsin had to get involved in these policies. Neighboring states had to coordinate their policies on a number of issues and still other policies had to be set at the national (federal) level. The airplane created still more complex problems, and commercial air travel could not function today without at least minimal international rules and procedures—for example a common language for international air traffic controllers and common safety and security procedures.

As I look at our national experience over the past 50 years or so, within my own lifetime, it seems that our policy response to problems created by ever changing technologies and new resources has moved from local to state to federal levels. I think this shift has been mostly the result of three factors: (1) Technology made the local community an inappropriate political unit for policy, thus the regulatory powers of government have shifted from the states to the federal level. One good example is in the regulation and control of the increasing number of complex chemical compounds used in many production processes. (2) Our large internal common market made policy at the state level an ineffective instrument for various forms of market intervention—e.g. farm policy, product safety, labor legislation, setting and monitoring standards, etc. These too are related to technological innovation resulting in an ever increasing labor mobility and a changing market structure of the economy. (3) Institutions at the state and local level have at times failed to protect equally the individual rights guaranteed by the federal constitution and so various questions of social, economic, and civil rights were appealed at the federal level.

The role of the federal government and our interpretation of appropriate action under the constitution also gets re-defined, especially in times of crisis. Our view of the appropriate role of the federal government in economic planning and intervention in the economy of the 1930s, or its role in defining and protecting the civil rights of all citizens in the 1950s and 1960s, are good examples of such re-definition.

I wish to emphasize that it is the level at which policy is *formulated* that has shifted to the more comprehensive political unit. Managing the consequences of powerful technology and avoiding chaos through relative uniformity of rules must be addressed by policy at this higher level. Implementation, of course, may remain at the local level. And I certainly do not minimize the very important, creative and experimental nature of state and local governments in tackling problems and setting patterns for action later taken and made applicable at the federal level. This has been a common pattern throughout our history. One of the areas in which we see this local experimentation operating today is in the variety of community land trusts, public development corporations and collective property rights institutions. I also admit to the likelihood of decentralization in the private economy and even new prospects of cottage industry based on the computer as suggested by Alan Toeffler in *The Third Wave.* Yet while this may be one impact of computers, their increasing power and complexity and potential for misuse is also bringing more federal concern and control.

This interacting process outlined earlier—new wants, new knowledge, new techniques, new resources, new conflicts, new policies, new institutions, and yet additional new wants, etc.—is not new. What has changed and *what is relatively new* is the power and scope of our modern technologies. The consequences of many modern technologies cannot be confined to local communities, and in many cases cannot even be confined to the political units called nations. Ours is a world, says Harlan Cleveland,

> "where science, which has always been transitional, keeps inventing inherently global technologies—for weather observations, military reconnaissance, telecommunications, data processing, resource sensing, and orbital industry. As a result . . . we find ourselves moving beyond concepts of national ownership, sovereignty and citizenship to ideas such as the global commons, the international monitoring of global risks, and 'the common heritage of mankind'" (Cleveland, 1985).

We live now in a world of increasing economic interdependence among nations whose institutions remain geared to addressing problems within their own national boundaries. But the scope and reach of global technology has consequences beyond the control of these national institutions. Despite the size of its economy and its sophisticated science, the United States is tied into this web of interdependence just as other nations are. We can no longer withdraw from the world and return to the isolationist ideology of a century ago, nor can we dominate the world, a role more or less dictated to us by circumstances for 20 years after World War II.

The US now depends on foreign sources for more than half of its supply of 15 minerals crucial for our industrial and post-industrial technologies. For 8 of these minerals, import dependence runs between 80 and 100 percent. Oil production within the US is not likely to see a major spurt and we will probably become increasingly dependent on oil imports. Our agriculture and parts of our manufacturing industry depend heavily on foreign markets.

One important change in the world economy has been the dramatic increase in world wide trade. The dependence of the US economy on international trade tripled in the period 1965-1979. A corollary of this increased trade is an economy less amenable

to direction by domestic economic policies. These last twenty years, concludes G. Edward Schuh,

> "have been a period in which the economic integration of the international economy has far outdistanced its political integration. In fact, we have witnessed a successive breakdown and growing irrelevance of international institutions at the very time that our respective economies have become increasingly integrated. Domestic economic policies have less and less relevance in today's world, and do little more than create suspicion and lack of confidence in national governments since their policies do less and less what they say they will" (Schuh, 1985).

"No nation," concludes Harlan Cleveland, "controls even that central symbol of national independence, the value of its money; inflation and recession are both transnational."

Perhaps the closest we have come to a really transnational institution with power to enforce its decisions is the increasingly complex multi-national corporation. Although they have been much criticized for some of their international practices, often appropriately, it is almost impossible to conceive of the world economy functioning without them. One-fifth of the world's gross product is created by these multi-nationals—more of them based in the US than anywhere else. In many commodities, world trade is dominated by the multi-nationals, and a large part of registered international trade is indeed the internal transactions of these international companies. With cheap and rapid transportation and instant communication, these large multi-national corporations have the capacity quickly to shift capital, technology and management all over the world. Is it any wonder that national policies do less and less of what they say they will?

Strong *economic* interdependencies, however, are not the only global ties among nations. Another major consequence of modern technologies is their environmental impact. More and more species are threatened with extinction. The burning of greater amounts of fossil fuels and widespread deforestation in various parts of the world raises the CO_2 content of the atmosphere. Acid rain and dying forests are not confined to the areas where the sulfur compounds enter the atmosphere.

Of course, the most powerful and potentially destructive technologies of all are nuclear weapons. This has led many to re-evaluate the meaning of "national security"—concluding that such security is not likely to be found in more weaponry of increasingly devastating power. There is, says Thomas Wilson,

> "an unavoidable nexus between the security of a nation and the state of the planet; there is a connecting link between the peace of nations and the integrity of natural systems; there is a critical relationship between international order and ecological balance. Indeed, the threat to the security of nations today is much more easily comprehended from an ecological than from a military perspective. This point is made with great force by the . . . 'Nuclear Winter Study'" (Wilson, 1985).

Modern science and technology have brought new possibilities for global (and indeed extra-global) actions and impacts. The reach and power of some of these technologies have consequences that cannot be contained in national decision-making systems. The human drive to "control nature for human purposes" must itself be controlled to avoid the potential widespread destruction of natural systems, without which human life would be impossible. The international institutions thus far created are not yet capable of dealing constructively with the global problems that modern science and technology have borne.

My comments should not be interpreted as being in any way anti-science or anti-technology. The earth's 4-5 billion people and the many yet to be added before world population levels off (even with the best of efforts and the use of new technologies) cannot be fed without continued developments in science and technology. Nor can

critical soils and fragile environments be protected and preserved without new scientific knowledge and its well-designed technological application. These must be selective developments, to be sure. All that is new and all that is possible is not necessarily desirable. We must by all means give as much public policy and institutional attention to alleviating the negative socio-economic and environmental consequences of technological developments as we do to the fostering and the diffusion of new technologies. Science and technology have negative consequences as well as positive ones. But those negative consequences are likely to call for more research, new knowledge and additional developments in technology.

In view of these urgent global problems, national policies often seem petty and contradictory. Said Saudi Prince Sultan Saud as he looked out the window of the space shuttle Discovery, "Looking at it from here, the troubles all over the world and not just the Middle East look very strange as you see the boundaries and borderlines disappearing. I think lots of people who are involved in causing most of these problems ought to come up here and take a look."

Must we wait for world government before any progress can be made in controlling these potentially destructive trends? We should recognize that some progress has been made on a variety of issues. International need not always be global and involve all nation states. In several areas nations in a particular region are working together on common problems. In other regions, of course, adjoining nations are at war. We are not very far along the path of creating appropriate institutions and enforcement powers to control some of the threatening consequences of the new technologies. In a view that's probably over optimistic, Thomas Wilson (1985) concludes:

> "If national security is dependent upon world security . . . if there is no other way to save our own outstretched necks—then the imperative drive of national interest in national security impels governments not toward divisive and hostile behavior but toward cooperative and collaborative behavior in world affairs, whether they like each other or not."

There is an urgent need for new institutional forms to deal with the complex issues threatening the global economy and environment. Fashioning such transnational institutions would be more easily accomplished in a world at peace rather than a world of suspicious and warring nations. Individual nations, especially the biggest and the most powerful, must seek cooperation and accommodation rather than threats and confrontation, dialogue and debate rather than accusations and denunciations.

As educators, we must recognize that many issues can no longer be kept in separate compartments for domestic and international solution. Most major domestic policies of the United States have significant effects on almost every other nation. What the United States is able to do, or wants to do, also depends increasingly on the acts and policies of other countries. That is what interdependence means. Educators at all levels must be aware of the fact that in a democratic system where people are the ultimate policy makers, individual citizens must be taught to understand these complexities. And elected officials must be able to comprehend these issues so they can help educate the public and provide the informed judgments required for sound policies.

In analyzing the need for institutional change to resolve domestic conflicts and attempt to make private, individual action consistent with the larger public purpose, the late John R. Commons, Wisconsin's great institutional economist, suggested that it is quite reasonable to expect that individual action is intended to serve individual goals and purposes. The real question, however, is whether individual action also furthers, or at least does not conflict with, the larger public purposes, or whether it serves *only* private purposes (Commons, 1924). We might paraphrase Commons and suggest that individual

nations today must see their own policies in a similar light: it is not a question of whether their policies should serve their own national purposes, that must be taken for granted. But the real question is whether national policies also advance, or at least do not conflict with, the broader international public purposes. In our increasingly interdependent world, self interest must be reevaluated constantly. Following a course of narrow self interest, whether at the individual level or that of the nation state can be self defeating and destructive.

We must learn to extend our sense of community to peoples in far away places with customs and beliefs quite different from our own. Extending and identifying our self-interest within ever-widening contexts is a basic ingredient of human history. For most people the nation state was the latest of these extensions. But these urgent global issues now require that we extend our empathy to other people around the world. Achieving this is the fundamental role of new institutions. This, of course, requires a positive effort on all our parts to understand other peoples and their cultures, their languages, their history and their aspirations.

We are born into a world of going concerns and established institutions. We essentially inherit a system and take its governing institutions pretty much for granted. Most of us do not get involved in creating new institutions. At best we help to reshape the ones we inherited, and then usually only marginally. Creating new transnational institutions to deal with truly global issues, whose rules and procedures provide mutual benefits and mutual restraints for the weak as well as for the powerful will be an immense task. We must not underestimate the difficulties involved. But neither can we withdraw and fail to address these issues—in our schools, at our universities, in political debates.

It does, perhaps, call for a new type of citizenship, where the responsibilities of citizenship are defined in a broader context. We must be ever conscious not only of the lives and the needs of other humans on this space ship earth—this global village. We must also be increasingly sensitive to the protection of the natural systems which sustain us. In closing, I should like to quote from a 1922 book by L. P. Jacks entitled *Constructive Citizenship.*

> We human beings are apt to think our race the only object in creation that really matters. We have developed a kind of class-consciousness in presence of the universe. The human race is all-important in its own eyes: nature is there to be ruled by us; her forces are meant to turn our wheels; her materials to be exploited for our enrichment; her laws to provide for our comfort; and the very stars in their courses must be yoked to our wagons. We have still to learn that the human race is tolerated in the universe only on strict conditions of good behavior. If we neglect our citizenship there, or think that we can play fast and loose with the laws that are written there, laws that were not voted into existence by us, those other citizenships will come to grief. This human class-consciousness in presence of the rest of the universe is not a good thing. It is a dangerous thing. Unless we bear that in mind, our study of the rights and duties of the citizen is not worthwhile (Jacks, 1922).

References

Cleveland, Harlan (1985), "The Passing of Remoteness," HHH Institute Newsletter, University of Minnesota, May, Volume 8, No. 1.

Commons, John R. (1924). *Legal Foundations of Capitalism,* MacMillin Company (republished in 1957 by University of Wisconsin Press).

Jacks, L. P. (1922). *Constructive Citizenship,* London: Hodder and Stoughton, Ltd.

Schuh, G. Edward (1985). "The International Capital Market as a Source of Instability in International Commodity Markets," paper given at the XIX International Conference of Agricultural Economists, August 26-September 4, 1985, Malaga Spain.

Wilson, Thomas W. Jr. (1985). "The Global Environment and The Quest for Peace: A Revolution In The Scale of Things," *Social Education,* March.

"THE MAN WHO LIVED AMONG THE CANNIBALS": MELVILLE IN MILWAUKEE

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Early in 1886, after years of literary silence, Herman Melville began writing his last book, *Billy Budd.* He died five years later, virtually unnoticed, because many people believed that he had died years before. In fact, in twenty years of employment as customs' Inspector for the Port of New York Melville continued to write but published only a small volume of Civil War poems for public sale. He also wrote *Clarel* and another volume of poetry, both printed in limited editions for his family and friends. Therefore, the final phase of Melville's public literary career—and his last work in prose before *Billy Budd*—was a brief attempt at lecturing, during which he once toured the Midwest and spoke in Milwaukee.

Melville met with decidedly-mixed success over these years, 1857-60, and it became clear to him that he would not make much money, nor would he revive his popularity as the author of adventure and travel narratives. The lecture tours were really his last efforts to maintain a career as a popular writer, and their ultimate failure probably accounted for his decision not to make a prose romance out of his last adventure, his trip to the Holy Land in 1856-57, but the philosophical poem *Clarel,* written for intimate acquaintances. His first lecture was "Statues in Rome," adapted from this trip; his last was called "Traveling."

Ironically, his nearest success on stage went back to the beginning of his career. The lecture he delivered in Milwaukee and elsewhere his second year on speaking tour was "The South Seas," actually fitting the reputation he worked so hard to overcome as "the man who lived among the cannibals," as he summarized his reputation in a letter to Nathaniel Hawthorne.[1] It became certain, finally, that he could not appeal to audiences as an entertainer, like the reigning stage star Bayard Taylor and the later star, Twain, nor could he be accepted as a philosopher or social commentator, like the reigning sage of New England Ralph Waldo Emerson.

Melville spoke in Milwaukee on February 25, 1859. By the time he appeared there, a late stop during the second lecture tour, he was working much harder to please local crowds than most critics have assumed.[2] His subject, content, and delivery were calculated for stage success. However, the Milwaukee performance was fairly typical in its dubious outcome. In books, Melville could be risque, impudent, even raucous. However, this character he found only through literary personae; Melville in person was urbane, often subdued, even shy and uncomfortable among strangers. He lacked Twain's talent for embodying his literary characters. Melville in person was usually a New England gentleman who remembered his genteel roots. (With the possible exceptions of James Fenimore Cooper, James Russell Lowell, and Emerson, Melville had more claim to New England gentry than any of the prominent nineteenth-century writers.)[3]

Melville was thirty-seven when he decided to try lecturing, thirty-nine by the time he appeared in Milwaukee. He had been a writer for thirteen years and a farmer, too, for half that time; but now, with a chronic back problem that would plague him the rest of his life, he was forced to rely almost entirely on his father-in-law to support his family. Normally active and independent, Melville was irritated by the prospect of a

sedentary life and family charity. He had already realized what many other writers more salable than he had found: few people could earn a living as an author, but several supported themselves writing and giving live appearances, by traveling the lyceum circuit. Melville was now unusually pressed for money. He was overdrawn on his accounts with publishers. One publisher of two recent books had gone out of business and was selling its plates, and another had lost its stock of some earlier books in a warehouse fire. Melville had nothing new ready for sale, having just returned from his trip to the Holy Land. A series of lectures seemed a practical venture for turning his recent excursion into something immediately profitable. So Melville wrote "Statues in Rome," an analysis of the philosophy of art, with an added dose of gossip and personal anecdotes. He knew the subject would attract little interest in itself.[4]

This first lecture, delivered through the 1857-58 lecture season (the winter months), generally received poor reviews. It was not a shrewd choice of topic for one whose forte was tale-telling rather than descriptive or critical analysis; moreover, reviewers generally agreed that Melville's delivery was rather dry. He had hoped for publicity to generate invitations and was thus disappointed. In addition, the reviewers tended to focus on characterizing the man who lived with the cannibals, rather than the author of a piece of statuary. Audiences preferred a glimpse of an entertaining personality, rather than a systematic analysis of works of art which they could not see before them. Nonetheless, he was sufficiently encouraged, and paid, to plan a second season in a more business-like manner. He began a correspondence to arrange a professional circuit from New England, into the Southern states, and through the Midwest, rather than waiting for invitations.[5]

An old family friend, William E. Cramer, editor and owner of the *Milwaukee Daily Wisconsin,* undertook the local publicity and might even have suggested Melville to the Young Men's Association, which sponsored the Milwaukee appearance. Melville spoke in Albany Hall, appropriately named to suggest that the city's cultural tastes were as refined as those of an eastern city, and Cramer appealed to civic pride, pointing out in advance notices that a well-attended lecture "always gives a stranger a good impression of the intellectual culture of the city."[6]

Melville had a promising field before him in Milwaukee in 1859; the city was growing and its affluent citizens eager to show their interest in things cultural. The Young Men's Association was composed, like many similarly-named groups in the Midwest and across Wisconsin, of business and professional men who were accumulating a library, presenting lectures and debates, and offering educational courses from a variety of cultural topics. A Young Men's Association or Young Men's Library Association existed in Beloit, Columbus, Fond du Lac, Janesville, Kenosha, LaCrosse, Madison, Oshkosh, Portage, Racine, Sheboygan, Watertown, Waukesha, and Waupun. They shared the name and corresponded on arranging programs, although they had no state-wide organization.[7]

In the 1850s, lyceums grew faster in the Midwest than any other part of the country and continued their popularity into the Civil War years. Chicago, Sheboygan, and Milwaukee were among the best stops for a speaker; the cities usually drew large crowds and offered good money—$50 a night was standard in eastern cities but only a few such stops existed in the West. Bayard Taylor once wrote from Milwaukee, "The people are infatuated. If I lecture next winter, I can spend three months in the West and have engagements for every night." This was Taylor's impression in 1854, when Milwaukee also heard such speakers as Emerson, Horace Mann, and Horace Greeley.[8]

Nonetheless, the midwestern audience was a somewhat difficult one for New Englanders. Newspaper reviewers were antagonistic

toward any Easterner who showed the slightest trace of snobbery or disrespect for the culture of the West; in addition, the character of midwestern audiences and their expectations sharply differed from those in New England. The Young Men's Associations attracted people with social expectations and pretensions, but these lyceum organizations in the West belonged to a second phase of the movement and lacked its original New England roots in the drive for popular literacy and free public education. By the standards of the time, Wisconsin had already accomplished such improvements in its first decade of statehood. Consequently, audiences in this state and others in the Midwest demanded as much entertainment as edification and were generally unreceptive to speakers who appeared as though they wanted to "school" the audience.[9]

For instance, Cramer's paper pointed out that Melville's lecture was "entertaining" and "*also* instructive" (emphasis added), suggesting the educational material was secondary. Cramer wrote that Melville "lay open a field of *adventure* and *wanderings* to which one rarely has his attention called" (emphasis added). Melville found out that reviewers were quick to bristle at the suspicion that they were being patronized or treated like uneducated backwoodsmen. Milwaukee's literacy was accomplished in part by German immigration, half the city by 1860. The German population in particular regarded itself as better educated and cultivated than other nationalities, including the native Americans, and very much resented being considered a pioneer settlement.[10]

When Melville first published south-sea adventures like *Typee* and *Omoo,* he had been accused of romantic exaggeration of the exotic island life. His new lecture on "The South Seas," however, now brought occasional complaints among midwestern reviewers that he was rehearsing well known material which any library could yield. For once, Melville found himself accused of a want of originality and a failure to be sufficiently exotic and entertaining.[11] The *Milwaukee Daily Free Democrat,* for instance, commented, "On the whole, we think there are few who knew much more about the South Seas, after he concluded, than before he began." Melville had said that this lecture was not to be a personal narrative—"a great mistake," said the paper, "for had he stated some of the scenes which he had passed through himself, and thereby invested his lecture with some life, instead of telling us what the primary geographies told us in our schooldays, he would have created a better impression in Milwaukee."

The starting time for Melville's lecture was moved up a half-hour so that Albany Hall could offer a held-over performance of Father Kemp's Old Folks Concert Troupe, a costumed choir and orchestra with a variety of sacred and patriotic music. The choir alone numbered thirty-seven people; the group was billed as "The Largest Concert Troupe in the World." Melville was in competition with a musical extravaganza, and although the auditorium was reserved for him, he was obliged to defer to the more popular show. In fact, the newspaper advertisements for performances at Albany Hall and elsewhere indicate a demand for drama and musical entertainment. Other selections in the winter season included a "Grand Masquerade Ball" and "St. David's Vocal and Instrumental Concert." Melville's competition on February 25th at Johnson's Atheneum was selections from *The Merchant of Venice* and *Rob Roy.* The Atheneum was also booked for *Uncle Tom's Cabin,* partly a musical on stage, and *Ten Nights in a Barroom,* starring the popular cracker-barrel comedian "Yankee" Locke. Such variety acts of the lyceum stage have been called "prevaudeville."[12]

The advance publicity for Melville's lecture billed him as the author of *Typee,* his first book of south-sea adventure—not as the author of any metaphysical allegories,

like *Mardi* and *Moby-Dick,* that were not selling now. Cramer had specifically reminded people that Melville had lived with cannibals and experienced episodes beyond the wonders of imagination. He did have exactly the kind of material that might keep an audience spell bound. Bayard Taylor was due in town for the Young Men's Association the next week, and his stage personality suggests what the audience preferred. Taylor, popular as a world traveler, wore costumes of places he described; his best known outfit was a pseudo-arab costume complete with scimitar. He avoided being a moral observer and spiced up his lectures with exotic-sounding poetry. He avoided using a script and the appearance of delivering a packaged performance. The *Daily Wisconsin* called his manner "enthusiastic" and "eloquent," noting his handsomeness made him popular particularly with the ladies. He spoke in Milwaukee on "Life at the North," travelogues being among the most popular stage programs. Taylor had accompanied Commodore Matthew Perry in the Pacific and had also some claim to being an expert on far-western islands. Taylor was willing to make money as a specimen from unknown parts of the world, an entertainer with adventure stories.[13] However, Melville, as everyone knew, had lived with cannibals and had experiences as wild as anything that Taylor might describe.

Nevertheless, Melville could not compete as a comparable entertainer, although he did make certain efforts to please his audience. He announced that this lecture was not to be an intellectual argument, but a collection of facts and impressions without a theme. Even his choice of material was a concession to popular taste. However, Melville's Pacific travels were fifteen years old and his memory less vivid than Taylor's. Melville had outgrown his former character. So he did not put all his material into the form of a personal narrative and actually opened with a summary of literary references on the South Seas and geographical information before recounting any of the "exceptional phenomena" that his audience had come for—indeed, was led to believe they would get, according to the advance publicity. In fact, there was little on cannibalism and no lewdness. Melville did attempt to appeal to the audience taste for the exotic and sensational with description of the bizarre "devilfish," the art of tattooing, and a sly reference to the "awful ceremony" of the taboo, a subject he said that he could not reveal in such a proper atmosphere as this, although it contained strangeness transcending the wildest romances of Mrs. Radcliffe. He spoke about Free Lovers, Mormons, and various utopian societies seeking asylums, all objects of public curiosity at the time.[14] He recounted an anecdote of meeting a Professor of Moral Philosophy who had abandoned civilized life for the sylvan retreat of the islands and three wives, the kind of sailor's yarn that the reviewers could question (in good nature) and appreciate for its romantic sentiments; overstepping the bounds of the probable and decent might be dubious history and morality, but good theater. He even worked in a reference to the Newall House, a stylish Milwaukee hotel, to contrast primitive culture to civilized society. Imagine, he said, a bare-limbed savage with awful tattoos appearing at such a proper place; this image might appeal to civic pride, and, at the same time, the touch of titillation made good theater.

On the whole, however, Melville was "packaged" more obviously than an audience would desire. For instance, one attempt at describing sea colors, which reviewers noted, has a consciously rhetorical and literary style. Here is Melville's text, in an exaggerated gothic style with allusions to the Bible and *Paradise Lost:*

> I have been in a whaleboat at midnight when, having lost the ship, we would keep steering through the lonely night for her, while the sea that weltered by us would present the pallid look of the face of a corpse, and lit by its spectral gleam we men in the boats showed to each

> other like so many weather-beaten ghosts. Then to mark Leviathan come wallowing along, dashing the pale sea into sparkling cascades of fire, showering it all over till the monster would look like Milton's Satan, riding the flame billows of the infernal world. We [theater audience] might fill night after night with that fertile theme . . . and tell of the adventurous sailors. (165-66)[15]

However, Melville dropped the scene for that night and had nothing marvelous to develop from such supernatural portent. He made no real effort at suspense and delivered the description without any spontaneity or sensationalism in which the audience might participate. The *Daily Free Democrat* thus complained that Melville offered few illustrations beyond general comments, cut short the personal anecdotes, and then gave "word-painting" rather than anecdotes with "any inherent or thrilling interest."

Melville was most emphatically himself in an ironic passage criticizing missionary work as personal gain, jingoism and colonialism, and Emersonian optimism:

> [T]he result of civilization, at the Sandwich Islands and elsewhere, is found productive to the civilizers, destructive to the civilizees. It is said to be compensation—a very philosophical word; but it appears to be very much on the principle of the old game, "You lose, I win": good philosophy for the winner. (179)

Although he announced no theme to his lecture, Melville had an explicit message: leave the islands alone. He told his audience that Americans should have no pretensions of civilizing other people until they civilized themselves. He meant no particular criticism of his audience here, although such a remark was ill-placed in Milwaukee, especially before people who subscribed to a lecture program chosen to represent a highly-refined, established culture, and who were also drawn to hear Melville by Cramer's advice that they show interest in intellectual offerings. As in the reference to the Newall House, Milwaukeeans wanted to be complimented for their civilization. They may indeed have come principally for entertainment; however, they were not going to applaud heartily for someone who would lift the veil only slightly upon the voluptuary life of the South Seas they imagined, and who then told them that they had no right to gawk upon the rest from any superior perspective. Bayard Taylor encouraged audiences to imagine themselves in foreign lands; Melville told them to stay home and civilize themselves.

In the words of Cramer's review in the *Daily Wisconsin,* adventurers had "no right" to interfere with existing cultures. The United States should leave Hawaii alone and thus keep it from "the demoralizing associations of modern civilization." Even Cramer, who was determined to be sympathetic to Melville in his paper, did not comment on the sentiments his friend expressed. He would not criticize him, but Cramer could hardly tell the civilized people of Milwaukee that they were no better than naked savages and that the tattooed Polynesian would be as amused by the elegant functions in the Newall House as its patrons would be by him. Cramer did little more than summarize the lecture after some opening impressions of Melville as a speaker. He wrote favorably of Melville and his delivery, endorsing the lecture as a whole, but avoiding specific support for the themes.

The *Daily Free Democrat* had no restraint; the audience would have preferred, it said, "personal reminiscences . . . to such bombast." So, "The lecture was attentively listened to," noted the reporter, "but the appreciation of it, we think, was testified by the limited applause at the close. The Association, we think, received more profit from the lecture than the audience." The snide remark that the audience had not gotten its money's worth was about the worst judgment a reviewer could pronounce. People were not going to quibble too much about a speaker's sentiments, so long as the speaker was entertaining. For this one ob-

server, at least, Melville had not passed the crucial test. The *Daily Free Democrat* said Melville had a "large audience . . . perhaps the most of whom were disappointed in the lecturer." He gave "a literary effort below mediocrity, unless he intended it as a reading. In fact, it seemed as though he had one of his romances before him, and had selected the most uninteresting passages to read for our edification." The audience listened "attentively," according to this report; however, newspapers invariably complimented local audiences so, sometimes the greater to criticize an uninteresting speaker. "[S]o general were his remarks that they failed to create much interest in the minds of hearers," the paper said.

The *Daily Sentinel* agreed that Melville had "an unusually large audience" to hear him talk about the beauties of the tropics "in his own inimitable way." The *Sentinel* offered little actual review and principally summarized the lecture, as the *Daily Wisconsin* had done. Only the hostile *Daily Free Democrat* undertook a critique rather than a summary. Although the *Sentinel* would appear to have approved of Melville by its comment on his "inimitable" style, the compliment is hardly hearty and even has a certain irony. Familiarity with the idiom of newspaper reviewing in the nineteenth century suggests that the term was something of a cliche; it was often used in advance publicity in place of anything more precise, and in a review, it may mean only that the reviewer had not really observed anything remarkable. "As a lecturer," the reporter noted, "Mr. Melville sustains the idea we have formed of him in 'Typeer' [sic], a soft voluptuous ease is the predominant characteristic. . . . [T]he same drowsy enchantment that makes his writings so fascinating radiates from the speaker." The *Sentinel*'s reviewer might have been a subtle reader of Melville, if indeed he had read Melville, for few critics would have called *Typee* "drowsy enchantment." The book actually had been accused of lewdness, Munchausenism, and trumped-up criticism of colonial missionaries. Moreover, Melville read his new material from a script—only the *Daily Free Democrat* was unhappy for this—but, even though the *Sentinel* did not register any criticism of its own, its report of Melville's subdued manner was not generally an endorsement of stage skill. Audiences usually preferred a more animated speaker. In a sense, the *Sentinel* had called Melville "bookish," a term the *Daily Free Democrat* used as sharp criticism.

Cramer's review in his own paper was the only solidly-complimentary one that Melville received. The *Daily Wisconsin,* in fact, said a "very large and appreciative audience" heard Melville, although it did not judge the applause, as the *Daily Free Democrat* had done. The *Daily Wisconsin* denied that Melville read a "stilted lecture" nor indulged in "rhetorical flights," but instead spoke in "delicious literary languor . . . graceful and musical." Melville was not one for stage theatrics, but instead spoke "as one would like to sit down to a club room, and with the blue smoke of a meerschaum gracefully curling and floating away . . . dream for hours, even till the night wore away." Cramer's simile was appropriate; in fact, Melville was generally best in intimate surroundings.

Albany Hall seated about 800 people. The actual attendance can only be estimated—all papers called it "large"—but despite the *Daily Free Democrat*'s insinuation about the Young Men's Association profiting at the audience's expense, the receipts do not suggest a tremendously successful booking or a capacity crowd. The Association actually lost money on the particular performance. The ledger records $50.45 received at the door, $50 for Melville's fee, and another $29.50 for expenses. The door receipts do not include subscribers to the season lecture program, but there is no estimate of exactly how many members attended. Ticket prices were 25¢, the standard charge for stage per-

formances (Father Kemp's Troupe charged the same). At any rate, the "large" crowd did not draw enough from the public to meet expenses for the performance. A "large" audience was another standard comment in reviews and might often mean no more than an average crowd. For instance, the *Sentinel* specifically said that Father Kemp's concerts were "fully attended. . . . The Hall will be hardly large enough to hold all who wish to hear them," the paper predicted. The *Daily Wisconsin* complained that ladies were forced to stand.[16]

So, it is doubtful if Melville had anywhere near a full house. The Young Men's Association did not renew its invitation to Melville when he expressed interest in performing a third season. Melville did get bookings the next year in the East but received almost no response from places on his midwestern tour. Melville was not cut out to offer the kind of entertainment which inspired enthusiastic reviewers and return crowds, who had plenty of top-name talent to choose from. By estimates, Melville was only the sixth most popular of ten speakers on the Association's 1858-59 program in Milwaukee.[17]

Cramer's review in the *Daily Wisconsin* was favorable; the *Sentinel*'s was essentially noncommittal; the *Daily Free Democrat*'s was hostile. The *Daily Wisconsin* and *Sentinel* put Melville on page one; the *Daily Free Democrat* put him back on page three. All told, Melville did comparatively well in Milwaukee. He also appeared in Chicago, Rockford, and Quincy, Illinois, but got few good reviews, most observers agreeing that he had no distinctive stage personality, seemed too rehearsed, and spoke too softly. The eastern reviewers had been generally favorable about "The South Seas," but there was, ultimately, little encouragement for trying the midwestern states again. Melville only performed in ten cities during the 1858-59 season, and although he made more money than he had the year before in sixteen cities and was apparently becoming more comfortable on stage, he had not done well enough to expect a new career as a lecturer—particularly if he had to rely on pleasing western audiences. In Michigan, Bayard Taylor wrote a parody of "The Raven," comparing the bird's "nevermore" and the student's vain efforts to escape, to fans and agents with speaking invitations rapping at his chamber door and allowing him sleep "nevermore." Melville had no such troubles to complain of.[18]

In addition, Melville had not managed to generate any new demand for the once-popular south sea narratives. He was already working on poetry in the summer of 1859, and, without much enthusiasm, looking into possibilities for publishing a first volume of verse. He also prepared a third lecture, as a more practical venture. However, to cancel his debts to his father-in-law, which Melville had been accumulating ever since his marriage, he agreed to deed his farm property to his wife, amounting to an admission of his failure as head-of-family and provider. The consensus among the family—Herman's too, probably, though he resisted it—was that he would have to find steady work and give up uncertain literary pursuits. He approved of efforts to find him a political appointment, although he did not actively pursue one.[19]

Lecturing was still his only immediate source of income, but his third season was the least profitable of all. Melville was so outwardly depressed and physically weak that family members suggested a vacation at sea again in 1860, as they had the year before he tried lecturing. He planned to go through the South Seas again; ironically, he became sea sick on the voyage out—the only time this had ever happened to him—and he cut short the voyage. When he landed in San Francisco, he decided to go home immediately. In fact, Melville received an invitation to read there, which he declined, although he had manuscripts with him.[20] By coincidence, Melville's final realization that he would

have to stay home and work at some routine came just before Mark Twain first lighted out for the western territories and began to find an idiom for himself as a world traveler and writer.

Melville's difficulties as a popular writer have been exaggerated and romanticized. He never was as much the deliberate outcast as some readers have thought; he never was an Edgar Allan Poe or Charles Baudelaire, writing what he thought profound to spite a public who never could appreciate him.[21] Even Melville's most critically-condemned and publicly-ignored books, *Pierre* and *The Confidence-Man,* were disappointments because he had thought that they would sell. Melville did not imagine himself essentially at odds with the bourgeois reading public, although he did finally realize that what talent he had as a writer would never make him rich or even provide a sole means of support. His lecturing, like his last romances, was a disappointment to Melville because he believed that it might work. But he found out, once again, that he did not have what it took to please the crowd.

Notes

[1] See letter to Hawthorne in *Moby-Dick,* ed. Harrison Hayford and Hershel Parker (New York: Norton, 1967) 556-60.

[2] Merrell R. Davis, "Melville's Midwestern Lecture Tour, 1859," *Philological Quarterly* 20 (1941): 57, suggests that Melville's South Sea lecture lacked spontaneity because he had no fresh observations on his experiences; and Merton M. Sealts, Jr., *Melville as Lecturer* (Cambridge: Harvard UP, 1957) 100-01, 121-23, believes that Melville "was thoroughly tired" of trying to rework the popular subject and, furthermore, had "grown alien to mid-century America."

[3] See comments from his cousin Henry Gansevoort in Jay Leyda, *The Melville Log: A Documentary Life of Herman Melville, 1819-1891,* 2 vols. (1951; rpt. New York: Gordian Press, 1969) 2: 600-01; Alfred Kazin, *An American Procession: The Major American Writers from 1830 to 1930—The Crucial Century* (New York: Knopf, 1984) 131-60; and Sealts 61.

[4] Leon Howard, *Herman Melville: A Biography* (Berkeley: U of California P, 1951) 211, 256-57.

[5] Howard 258-60; and Sealts 58.

[6] Newspaper reviews are taken from the collections of the State Historical Society, Madison.

[7] See Ralph M. Aderman, "When Herman Melville Lectured Here," *Historical Messenger* 9.2 (1953): 3; Carl Bode, *The American Lyceum: Town Meeting of the Mind* (1956; rpt. Carbondale: Southern Illinois UP, 1968) 174-75; and John C. Colson, "'Public Spirit' at Work: Philanthropy and Pubic Libraries in Nineteenth-Century Wisconsin," *Wisconsin Magazine of History* 59.3 (1976): 192-209.

[8] Bode 168, 175.

[9] Bode 98, 166-68; Davis 52-53; and Sealts 61, 83-84.

[10] Kathleen Warnes, "Milwaukee: The German Athens in America, 1835-1920," Wisconsin Academy of Sciences, Arts, and Letters Symposium and Conference, Wausau, 25 April 1986. None of the German-language papers in Milwaukee reviewed Melville.

[11] See Sealts 73-74, 94.

[12] Richard Nelson Current, *Wisconsin: A Bicentennial History* (New York: Norton, 1977) 147.

[13] See Bode 217-19.

[14] Sealts 64.

[15] The full text of "The South Seas" is reconstructed by Sealts (155-80). Page references for passages quoted in the test of this essay are contained in parentheses.

[16] Davis 47; Leyda 603; and Sealts 76, 93.

[17] Howard 261.

[18] Bode 218-19; and Sealts 92-93, 99-100.

[19] Howard 262-67.

[20] Howard 267-69.

[21] Kazin calls Melville a "captive to the commercial capital," New York City (137), and recalls that Sam Melville, the "Mad Bomber" killed at Attica State Correctional Facility in 1971, took his name for Herman, whom he identified with revolution (158). In addition, Edwin Haviland Miller, *Melville* (New York: Persea, 1975) 295, says that Melville could not resign himself to giving audiences what they wanted.

SIMULATION IN LANDSCAPE PLANNING AND DESIGN: THE ART OF VISUAL REPRESENTATION

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This paper examines the subject of visual representation in landscape planning and design by subdividing the subject into several related sub-topics including its relationship to environmental impact assessment and contemporary problem-solving, the benefits associated with simulation use and how that has led to the development of a simulation course at the University of Wisconsin.

A BRIEF HISTORY

Throughout history man has used visual representations such as drawings, paintings and three-dimensional objects to simulate visual modifications to his world. Some of the earliest simulations used by environmental planners and designers were pottery models built during the 1st and 2nd centuries AD in China. These miniature representations illustrating ornate wall and roof details were used to guide the wooden architecture of the time.[1] Other early simulations included maps, plans, sections, elevations, sketches and perspective drawings—techniques that are still in much use today. An early development by the landscape architect Humphrey Repton used illustrations hinged in such a way that both existing and proposed environmental conditions could be displayed at the same time. This technique using "slides" of proposed improvements could be flipped up to cover only those parts of the landscape to be changed. Repton believed this provided a far more effective means than maps or plans to help clients visualize the effects of environmental changes.[2] Similar overlay techniques are in wide spread use today and serve as the basis for much of the work produced by planners and designers.

Early techniques like Repton's slides which were dependent upon pen and ink, pencil, and watercolors were subsequently augmented by photography as a tool for visual representation. Initially in the nineteenth century, on-site eye-level photography became popular and later with the advent of World War II, aerial photography became available and gained widespread use. More recent advancements including the use of photo-mosaic and stereo-pair photography have greatly facilitated large scale analysis of land areas for design and planning.

Recent technological developments have made new visual tools available to land planners and designers including movies, video and computers for analysis and communication. On the horizon are the use of highly realistic computer-generated animations similar to those used in many recent "box office" hits.

This discussion might lead one to believe that there is an ever increasing reliance on the use of visual simulations in landscape planning and design. Such a conclusion would be only partly true. As noted, the practice of landscape planning and design has always relied on the use of simulations although it is now adopting the use of more sophisticated technological innovations.

The growing use of more complex and sophisticated simulation techniques in landscape architectural practice and research poses a new set of challenges for professionals. These include keeping abreast of new developments and understanding their strengths and weaknesses, limitations and opportunities, and knowing where to integrate them into the design and planning process.

Simulation and Environmental Impact Assessment

One of the most important single actions that has been devised to elevate the importance of environmental management and visual simulation in this country, was enactment of Public Law 91-190, the National Environmental Policy Act (NEPA) in 1969. The purposes of this legislation were:

> "To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and national resources important to the Nation; and to establish a Council on Environmental Quality. (42 U.S.C. 4321)."[3]

But what does this have to do with visual simulation?

The Act goes on into additional detail as exemplified in the next excerpt:

> "(b) in order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practical means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the nation may—
>
> (2) assure for all Americans safe, healthful, productive and esthetically and culturally pleasing surroundings;"[4]

The responsibility for carrying out this mandate at the Federal level is stipulated in Sec. 102 of the act as follows:

> "Sec. 102
>
> (A) Utilize a systematic interdisciplinary approach which will insure the integrated use of natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment."[5]
>
> The scope and purpose of NEPA extends beyond an analysis of the impact of proposed actions upon "esthetically and culturally pleasing surroundings."

One Federal agency that has taken this responsibility of exploring the area of visual impact seriously is the Bureau of Land Management, Division of Recreation and Cultural Resources. In 1980, a well illustrated report was published under the title VISUAL RESOURCE MANAGEMENT PROGRAM.[6] Whereas the document deals with the broader subject of visual resource management, one section is devoted entirely to "VISUAL SIMULATION TECHNIQUES." Several visual simulation techniques are described and illustrated and focus on such projects as highways, dams, power plants, and overhead transmission line structures to mention a few. In addition to these subjects, illustrations of various techniques have been provided as concrete examples of the effectiveness of various techniques to simulate proposed actions of various types of landscape conditions.

The leadership that was provided at the national level through enactment of NEPA was echoed by various states including Wisconsin. In 1971, Assembly Bill 875 was enacted and became known as the Wisconsin Environmental Policy Act (WEPA). Upon reading WEPA, the reader is struck by the similarities in purposes and language with NEPA. Whereas NEPA mandates environmental impact assessment by Federal agencies, WEPA focuses upon the mandate of conducting environmental impact assessments on certain specified actions that could have deleterious affects upon the environment of Wisconsin.

Unfortunately, the administration of WEPA has not been accompanied by consistent applications of visual simulations as a means of evaluating the acceptability of certain visual impacts that accompany developmental actions in Wisconsin.

The Role of Simulation in Contemporary Problem-Solving in Wisconsin

A number of recent case studies illustrate the usefulness of visual simulations in environmental decision-making. These applica-

Fig. 1a. A typical streetscene in a Wisconsin Community.

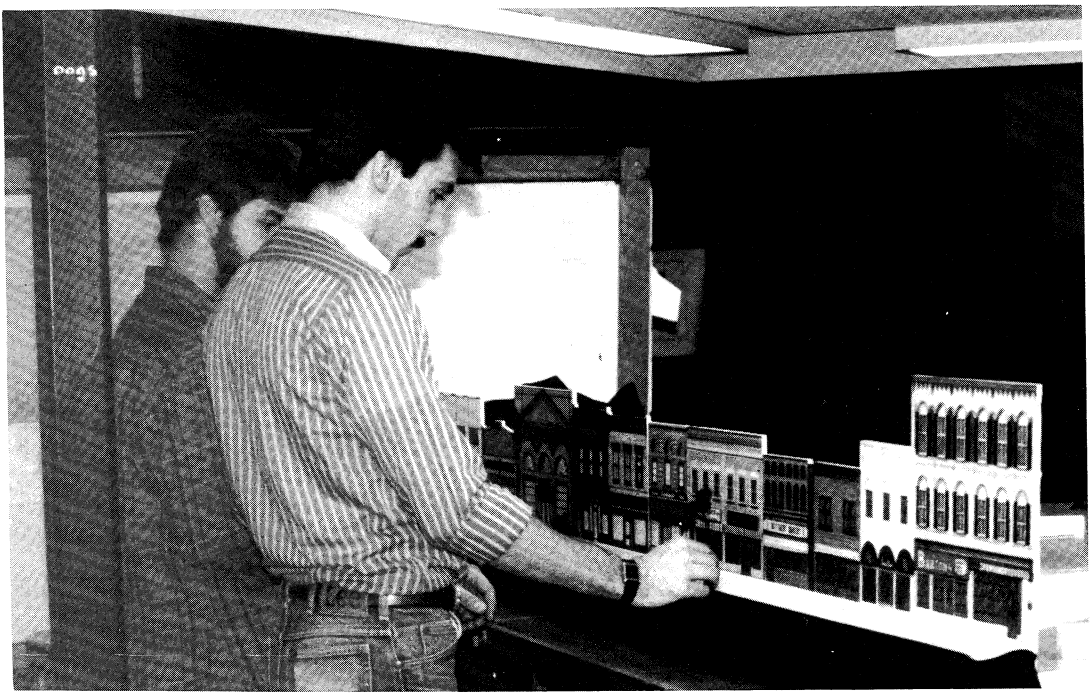

Fig. 1b. Three-dimensional model simulating proposed streetscene changes.

tions range in scope across political levels and the variety of available simulation techniques.

Wausau Sign Ordinance—

Hand-drawn simulations were recently developed for use by a grassroots organization in Wausau, Wisconsin to illustrate the impact of a proposed sign ordinance. From 35 mm slides of several urban streetscapes, illustrations of the existing scenes without signage were generated. Two drawings were then superimposed on the original illustrations; one depicting existing sign conditions, the other showing the changes necessary to comply with the proposed ordinance. This technique provided a quick and efficient means for illustrating the effects of the proposed mandate.

UW Band Practice Facility—

As part of a University of Wisconsin class exercise, landscape architecture students prepared three-dimensional simulation models to provide design recommendations for a proposed university band practice shelter. This proposed facility, to be built in an area providing unobstructed views to the bordering lake and along a notable segment of Madison's Park and Pleasure Drive system requires a design that is responsive to the area's character and sensitive features.

Again working from 35 mm slides of the area, a stage-set apparatus was built in which several scale models of proposed design solutions for the practice facility were placed. This combination of elements provided an opportunity to evaluate the models in terms of position, form, color, and texture against the "backdrop" of the existing context. As a result an exhaustive list of design recommendations were tested, evaluated and established before any construction took place.

Community Applications—

In the Fall of 1985, fourteen students in Landscape Architecture focused upon downtown Lake Geneva, Wisconsin. In this advanced design studio, the project scope encompassed social-demographic considerations, development of a land-use and open-space master plan and analysis and design of retail structures in the downtown district. Detailed elevation drawings, depicting how the appearance of each building could be improved, were created by the students.

An outgrowth of this project was a large model representing recommended improvements for each building in the four block area of the downtown (Fig 1a,b). The model, representing each of the eight blockfaces, was elevated to shoulder height, so that people could move through the model and experience how the downtown would look if recommendations were implemented. The model was also video taped by placing the video camera on a cart with the operator, and moving the cart through the space between each block of the model to represent the dynamics of driving through the downtown.

Overhead Transmission Lines—

Several years ago, B. Murray and B. Niemann (Professor, U.W. Madison, Department of Landscape Architecture) provided testimony concerning whether overhead transmission lines should be constructed in the vicinity of the Cross Plains unit of the National Ice Age Reserve (the Reserve). Among the numerous exhibits used were illustrations depicting the visual impact associated with overhead lines. Utilizing photographs of the site, with wood poles in place, including installed insulators, the electric lines were rendered in the photograph. This simulation served to illustrate how overhead transmission lines would alter views to and from the Reserve from certain vantage points within and around the Reserve. Graphite pencils were used to illustrate the variegated play of light on the surface of the lines. At certain times during the afternoon, light would be reflected from the lines creating white lines against a darker background of land and

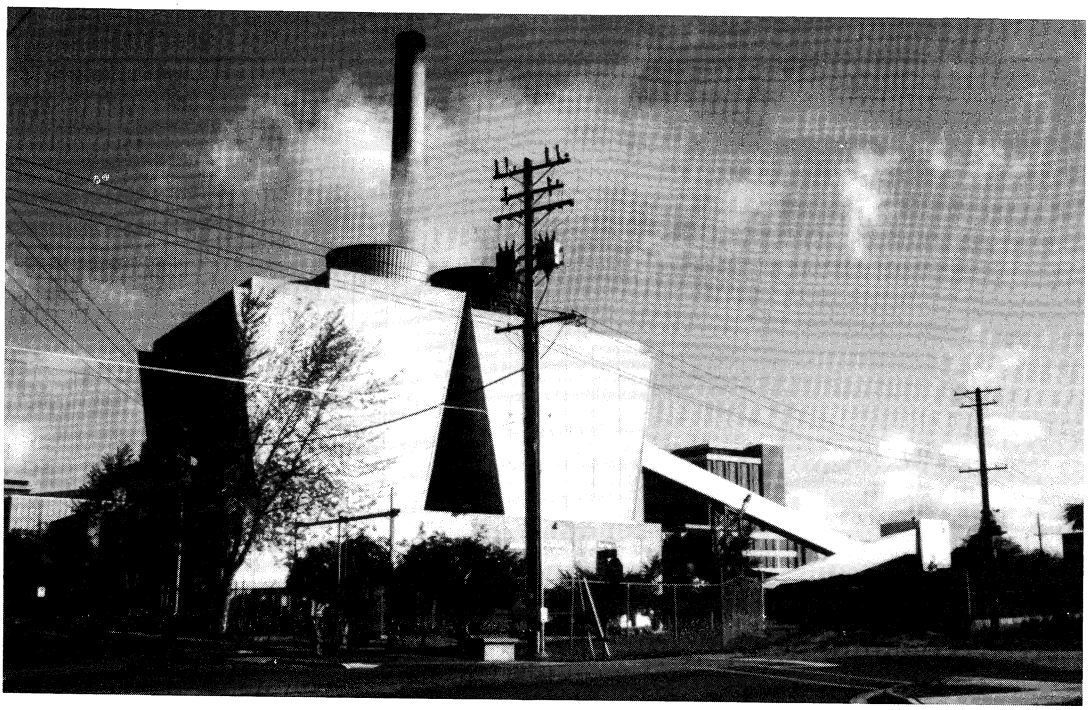

Fig. 2a. A University of Wisconsin heating plant.

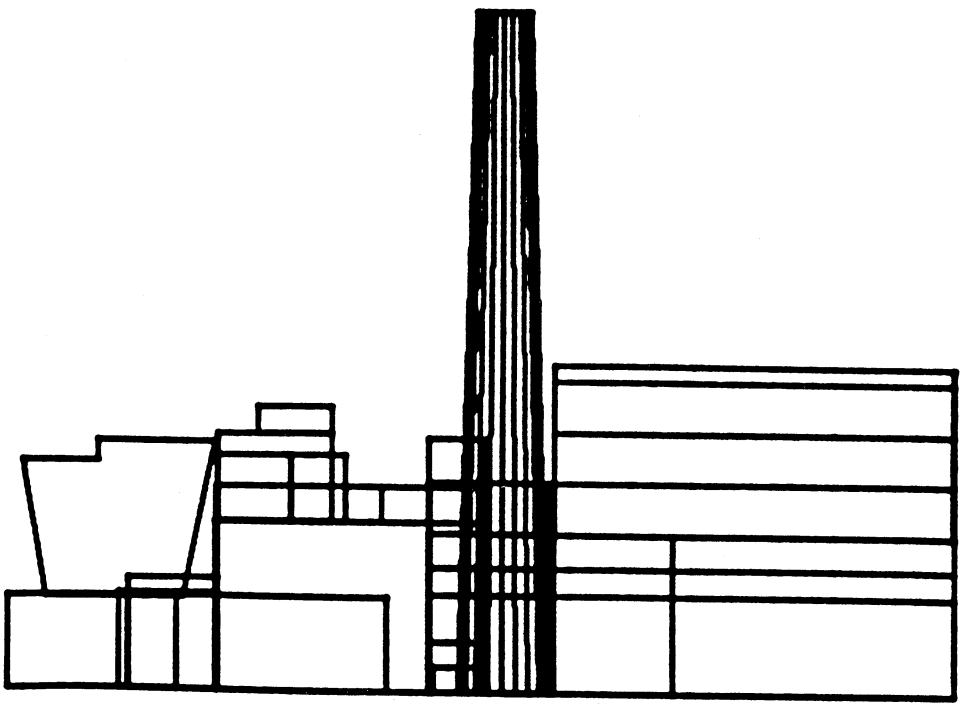

Fig. 2b. Computer-generated image simulating proposed building changes.

vegetation thereby increasing the visibility of overhead lines. The utility was subsequently required to place the lines underground in order to preserve the visual quality of the Reserve.

UW Emission Control Facility—

To illustrate the effectiveness of dynamic simulations in environmental planning, computer generated graphics were used to illustrate the addition of an emissions control system to an existing heating plant on the University of Wisconsin campus (Fig 2a,b). These images provide the viewer with the opportunity to quickly add or subtract the proposed addition to a plan, elevation or perspective view of the present structure. In addition, the computer images could be rotated to give the viewer the impression of "walking" around the structure. Such a dramatic technique not only serves the viewer with a vicarious experience of the setting but gives the designer the capability to quickly manipulate and evaluate several alternative solutions.

Benefits of Visual Simulation

While the reasons for using visual simulations and some of the past and present uses have been discussed, little has been said about the benefits derived from such work.

The principle objective associated with simulation use is the ability to evaluate alternative futures and proposed actions. For example, what will the environment look like, what will be the relationship of spaces, and what materials, colors, and textures should be used to complement the existing landscape?

Simulation is intended to provide valid, reliable, and useful information about the visual landscape to those who manage the environment, who promulgate and implement policy, and who plan and design physical changes in the environment. In other words, simulation is intended to provide information to improve the quality of decision-making with reference to environmental management as well as to change and modification. Simulation can also help identify and specify problems that will emerge that might otherwise be ignored or misunderstood. It can provide information based on empirical data rather than on guesses and intuition, thus providing an empirical basis for the establishment of new approaches to environmental planning, management and design.

Whenever growth occurs, environmental modification will occur. Hundreds of thousands of new environments are changed or created each year, ranging from individual housing developments to clearcutting on the National Forests. Evaluating all such environments after alteration would be an enormous costly and inefficient undertaking. One way to gain a better understanding of the impact of these changes on our visual environment is through simulation. Simulation studies provide a means for assessing the nature of the environmental impact before a project begins. This information makes it possible to modify, fine-tune, or abandon the proposal before any irreversible action takes place. Thus, simulation provides a cost-efficient means to evaluate a range of solutions and their associated costs.

Simulation can also be used to improve communication problems between and among participants involved in the design/planning process and enhance public participation by facilitating heightened understanding of potential impacts. In many cases, simulation is perceived as an integral part of the planning/design process. There are several reasons for this. First, it provides an early opportunity for interested parties to participate directly in the design/planning process. Second, it gives the user the ability to utilize the simulated options as an educational tool, informing clients as to what is possible and how the solution is responsive to the project objectives—that is, to their needs and wishes. And third, it gives both

the client and the designer/planner an opportunity to explore the meanings each derives from the several options.

Visual Simulation Course: Theory and Practice

It is apparent from the preceding sections that public policy legislation and review has resulted in the creation of instruments that require an analysis of environmental, economic and social impacts as a prerequisite for granting authority to proceed with certain types of development. It is also evident that visual simulation has been and is being incorporated into some decision-making issues. Lastly, the point has been made that benefits are derived from carrying out visual simulations that may either stand alone or accompany other aspects of environmental impact assessment. If one can accept the relevance of visual simulation, a cogent question requiring an answer is "how are individuals prepared to perform visual simulations through public and private entities and for many different types of clients?" Universities can provide an important resource for advancing the science of visual simulation. One response can be found in the Department of Landscape Architecture at the University of Wisconsin-Madison. In the Spring of 1986, a course entitled "Visual Simulation in Landscape Planning and Design" was offered for the first time. The purpose of this required course is to involve graduate students in the ethical, theoretical and practical dimensions of the art and science of visual simulation.

Conclusion

The profession of landscape planning and design is experiencing the growing use of more complex and sophisticated techniques for visual representation. As more techniques are developed and refined, landscape simulation will continue to be used as a means for evaluating the visual effects of human-altered environments. At present, however, the administration of public policies requiring visual impact evaluations such as NEPA and WEPA are not accompanied by the consistent use of simulations. This poses a new set of challenges for planning and design professionals. In response, the Department of Landscape Architecture at the University of Wisconsin has introduced a new course designed to help prepare and inform students about the advantages and potential pitfalls associated with visual simulation work. The authors believe it is evident from the case studies reported that the University has established a solid foundation in this important area in the education of future landscape planners and designers.

Notes

[1] Norwich, J. J. 1979. *Great Architecture of the World.* New York: Bonanza Books.

[2] Goode, P. 1984. Humphrey Repton. Landscape Planner: Avant la lettre. *Landscape Architecture.* 74(1):54-56.

[3] National Environmental Policy Act of 1969.

[4] *Ibid.*

[5] *Ibid.*

[6] Visual Resource Management Program. 1980. U.S. Government Printing Office: 0-302-993.

WOMAN AS EROS-ROSE IN GERTRUDE STEIN'S *TENDER BUTTONS* AND CONTEMPORANEOUS PORTRAITS

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As the blind glass of the opening still-life of *Tender Buttons,*[1] Gertrude Stein presents herself like the Greek seer Tiresias. She is our prophet, our Sibyl. And like Tiresias and the typical Sibyl, she is of ambiguous sex. While clearly female physically in real life, Stein thinks of herself as male in the great poetry of her 1913 *Tender Buttons*—one of the keys to this work that many baffled readers have missed. Earlier, in fact, in Stein's lesbian-autobiographical novel *Things As They Are,* Adele/Stein actually exclaims at one point,

> "I always did thank God I wasn't born a woman."

In "Objects," the second section of the triad "Objects," "Food," and "Rooms" that comprise *Tender Buttons,* Stein intends to view simultaneously, both subjectively and objectively, the world "out there." Understandably, things nameable emerge on her writing tablet in a complicated form. One half of Stein partakes of, yet criticizes, the hard handsome glory of the male spirit dominant in the second still-life of Tender Buttons, GLAZED GLITTER. But Stein's second half feels the debasement, yet soft sensual appeal of the female, seen in anthropomorphic, dualistic thinking as matter itself, and objectified in A SUBSTANCE IN A CUSHION, the third still-life of "Objects."

Characteristically, while the Sibyl takes an intellectual stance, she is not sexless; instead, knowing herself erotically drawn to women rather than to men, she comes into the position of Sappho. And the Sapphic passion—in Gertrude Stein's case her desire for Alice Toklas—is one of the ecstatic messages expressed cryptically in the tiny exploding still-lifes and in similar imagistic passages within the more abstract meditations of *Tender Buttons.* For while the sheer poetry of WATER RAINING, A PETTICOAT, RED ROSES, A SOUND, and multitudes of other little poetic bursts can be interpreted in a single dimension as statements about Pragmatic philosophy, often they also present fleeting insights into the charms of the female human being; and these erotic preoccupations emerge in phrases, lines, sentences, paragraphs, everywhere, just as Freud in *The Interpretation of Dreams* found human desire all-pervasive in the human unconscious. And if Gertrude Stein, Sibyl and Sappho both, thus mixed abstract philosophy with concrete poetry, it was inevitable. For Stein's chief endeavor in writing *Tender Buttons* was to effect a reconciliation between the competing claims within her of thinking and feeling, of the dualism in her own subjective being that she projects onto the shifting external objects of her contemplation.

To study Gertrude Stein's imagery presenting woman as aesthetic object in *Tender Buttons,* I will for the moment concentrate, with grossly simplified poetic analysis, on a single poem, one that seems among the least obscure and is certainly among the most charming.

A PETTICOAT

> A light white, a disgrace, an ink spot, a rosy charm. (471)

There happen to be exactly 17 syllables here, as in the Japanese haiku, if one counts the title as part of the poem—which of course one does not do in haiku, since haiku usually lack titles. What is important is that, like haiku, Stein's poem uses the *juxtaposi-*

tion of ideas and the connotations of words to create the message, rather than cause-and-effect logic. At first glance A PETTICOAT appears to promise a series of qualities defining a woman's undergarment, but a second look shows a certain light-hearted confusion—for an ink spot is not typical of petticoats! An ink spot is a sign of soiling, however, casting a blight on the white purity of the woman's intimate apparel, and perhaps by association, therefore, with the virtue of the woman's body beneath the petticoat too? Or is the implication that using ink, perhaps writing or the profession of a writer, damages a woman's femininity, signified by her rosily charming undergarments? The poem insists that some disgrace is involved in petticoats, or at least in one of these items. There is clearly what one almost always has in Stein: a riddle, a mystery—even an implied narrative.

From a strictly external view, the poem has the air of a perfect little song. The accented syllables of the title A PETT'I-COAT' and of the last phrase "a ro'sy charm'" are identical, as are the intervening three phrases, "a light' white'" and "a dis'-grace'" and "an ink' spot'" so that the whole can be thought of as either linear or circular, or both. And when finally the lost pattern of the title comes back in the final phrase, we breathe a sigh, fulfilled by the perfection. Assonance working behind the scenes along with alliteration gives the flounces needed to create the pretty petticoat.

Of course there is much more to A PETTICOAT than mere sound-charm. The sound-charm (magical incantation?) reflects the sense charm, ready to be fathomed. A petticoat is a little, light thing, a "female" thing as opposed to a big heavy garment like a male's overcoat; it is, moreover, an undergarment, an appropriate metapor for the more protected sex. Read in the context of its surrounding poems in *Tender Buttons,* AN UMBRELLA (an object which also flares out roundedly) and A WAIST (here described as gliding in slim charm like a star), the femininity of the petticoat is strengthened all the more.

A PETTICOAT begins with the phrase "A light white." What is the meaning here? The allusion may be to *difference* itself, with the reader's attention drawn to the fact that "white" is not merely an abstract idea, but exists in many different particular white things. Or perhaps as she often does, Stein is transferring a word or part of a word from its own place to another; and if she is using such a device here, "a light white" might be "a white light," perhaps a spotlight, or just a white dot or spot to contrast with the third phrase of this still-life, "an ink spot." As it happens, the still-life directly preceding A PETTICOAT ends with the word "dot." Such trails, like the fact that the poem directly following also contains the word "disgrace," must be followed as one unwinds Stein's twisting threads. Some appear less significant than others, but there is no avoiding the all-pervading color symbolism of *Tender Buttons.*

Returning to the idea of different shades of white, we might discover "cream" as one of the possibilities. Cream is not pure blazing white, but a yellowish-white color; it happens to be one of Stein's code-words for the delightful and fulfilling life. Associations with cream—milk, ice cream, custard, cows, the country, meadows, milking stools, even roast beef (the cow cooked) in Stein's writing signify hedonistic pleasure, both sexual and gustatory ecstasy: the joys of living. Hedonism and delicate, flippant joy in hedonism were expressed to perfection by writers in Stein's favorite period in English literature. Robert Herrick also wrote of petticoats[2] and the disgrace of "a sweet disorder in the dress." Stein's vocabulary in A PETTICOAT, both in word and thought, is interestingly similar to Herrick's, and his telling young women to gather rosebuds while they may in "To the Virgins to Make Much of Time" reminds one of Stein's virgin in IN BETWEEN, which deepens the erotic level

of A PETTICOAT (brackets below give my suggested reading):

IN BETWEEN

In between a place and candy is a narrow foot-path that shows more mounting than anything, so much really that a calling meaning a bolster measured a whole thing with that. A virgin a whole virgin is judged made and so between curves and outlines and real seasons and more out glasses and a perfectly unprecedented arrangement between old ladies and mild colds there is no satin wood shining. (472)

["In between a place" (place of delight; also, place is a chime for "Alice) "and candy" (the sweet of desire) "is a narrow foot-path" (a difficult place to travel) "that shows more mounting" (reference to mounting excitement, or mounting as taking a sexual position) "than anything. . . ." The "bolster" can be "the bold sister"; also, might be an age reference to Gertrude and Alice, several of which occur within *Tender Buttons,* whom Gertrude alludes to as "yellow" or "mellow" or as "mutton" rather than lambs in MUTTON; this poem in fact ends on the age question, with allusion to Gertrude and Alice's "perfectly unprecedented arrangement," which differs from one made between "old ladies" (sexually cold, presumably) and the hotter one between women like Stein and Toklas as "mild colds" (only mildly olds). "A whole virgin" (an intact virgin) is judged "made" (maid; also, made a virgin, but "undone" voluntarily). Stein plays throughout with the idea of "wholeness," "holeness," and perhaps even "holiness" and "evil" if the "satin" in the last phrase is Satan.]

Another suggestive little scene, here of intercourse and its aftermath, occurs in RED ROSES, the poem directly preceding IN BETWEEN:

A cool red rose and a pink cut pink, a collapse and a sold hole, a little less hot. (472)

[Something "red" (code word for woman, with the "something" here her private part; could also refer to male's organ) that was "cool" (not stimulated) "rose" (became excited and swelled; if male organ, became erect) while "a pink" (one person's pink part, lips or nipple or finger-"pinkie" or private part) "cut" (inserted itself into) "pink" (another's intimate body part). There was a collapsing (emission and/or deflation), and "as for the old hole, it was a little less hot after that"; or there may even be an obscene reference to "old ass hole." (I will not go into matter here, but Stein matches Joyce's early scene in *Ulysses* that shows Leopold Bloom performing his bowel functions with her *Tender Buttons* poems A BROWN and A PAPER.]

The poem that follows IN BETWEEN and RED ROSES is called COLORED HATS, and may be one of the clearest references in *Tender Buttons* to the trip to Spain that Stein and Toklas took as Gertrude ran away from the strained situation with Leo at their apartment at 27 rue de Fleurus and tried to decide what to do.[3] Avila was one of the places that Stein and Toklas visited and loved, and Avila is a place that happens to be famous for its colored hats. In *Avila* Camilo José Cela writes

> In the regions of Barco de Avila, Piedrahita, Hoyocasero—and occasionally in the city itself—we can still sometimes see women wearing the pleasing *gorra* of curled straw. It is a tall helmet-like hat adorned with different coloured wools . . . of material coloured according to a woman's condition. If she is a spinster the material is green, red for a married woman and black for a widow. It is curious to notice how often in their dress we see Castilian women wearing some adherence to colours indicating virginity, married state or widowhood. . . .[4]

With this in mind, one reads Stein's COLORED HATS with new understanding, finding in the poem meaningful references to women's married-state conditions like pregnancy ("broad stomachs") and childbirth ("the least thing is lightening") and to their virginity-associated conditions like menstruation ("custard whole"). One even sees a reference in COLORED HATS to the virgin "Saint Teresa, the "Little Flower" who is

everywhere worshipped in Avila, as well as a jocular reference to Louisa May Alcott's virginal *Little Women* and perhaps even to Pearl, the sinning Puritan Hester Prynne's bastard child. (In this quotation my interpretations occur within the quoted poem itself, enclosed in brackets. To making reading easier, Stein's own words are italicized.)

COLORED HATS

Colored hats are necessary to show that curls ["girls," indicated by a rhyming word and also by association of "girls" and "curls"] *are worn* [worn out, exhausted—what Stein had observed as a medical student helping to deliver babies] *by an addition of blank spaces* [extra spaces, thus pregnancy], *this makes the difference between single lines* [virgin's lines] *and broad stomachs, the least thing* [the baby] *is lightening* [makes the mother weigh less when it is born], *the least thing makes a little flower* [a little flow-er of water and blood, as well as a little flower or bud-baby, one saintly like St. Teresa] *and a big delay* [de-lay, pun of the lengthy laying-in process of birth] *a big delay that makes more nurses than little women* [children, virgins, also women little again after childbirth] *really* [materially, factually] *little women. So clean is a light that nearly all of it shows pearls and little ways* [weighs, weights, reference to matter]. *A large hat is tall and me and all custard whole.* (473)

The allusion to children in COLORED HATS, the little things that lighten broad stomachs, is repeated two poems later in A LITTLE CALLED PAULINE, where Stein announces that a "little" (a baby) called by any name whatsoever "shows" (signifies) 1) mothers (half-rhyme with "shudders"), 2) udders (perfect rhyme with "shudders"), 3) shudders (literal quivers in Stein, who while assisting in the delivery of babies as part of her medical training had been so appalled at the process of childbirth):

A LITTLE CALLED PAULINE

A little called anything shows shudders. . . . (473)

To return however, to the comparative innocence of PETTICOAT. Besides femininity, A PETTICOAT features another important Stein theme: her writing. This is the idea behind "an ink spot" (both pubic hair and "ink's pot") which leads ultimately to the relief of "a rosy charm." Alluring in her saucy undergarments, Miss Alice Toklas is a light white or white light beacon. She is also a disgrace if the world sees her as what she is, Gertrude's lesbian lover.

To support this contention and my interpretation of the petticoat poem, let us look at female figures in the portraits written at the same time of *Tender Buttons.* In many of these portraits Alice Toklas[5] is the heroine who comes to "save" Gertrude by her loving support and her erotic charms which awaken Stein to the poetry of life. Naturally, images of woman as eros-rose, Beauty, are more indirect in Stein's *Tender Buttons,* which seeks to personify through objects, than in her portraits, which attempt to render living people. The images of erotic woman in the portraits, while still disguised through obfuscating language, *should* be relatively easy to fathom, but for many critics this has not been the case, and many do not locate Alice Toklas behind all the multiple-image temptresses "Susie Asado" and "Preciosilla" and as the fellow gypsy with Gertrude Stein in "A Sweet Tail (Gypsies)." Richard Bridgman even discounts Carl Van Vechten's suggestion that the famous flamenco dancer la Argentina was one of the female images behind these portraits.[6] Similarly, other excellent critics such as Marjorie Perloff in *The Poetics of Indeterminacy,*[7] James Mellow in *Charmed Circle: Gertrude Stein & Company,*[8] and Wendy Steiner in *Exact Resemblance to Exact Resemblance: The Literary Portraiture of Gertrude Stein,*[9] all appear confounded because there may have been more than one dancer seen by Gertrude and Alice in their wanderings in Spain when the portraits were written, or for other overly-specific reasons. However, if one

allows that multiple, ambiguous identifications are true, but that behind them all is invariably the figure of Alice Toklas, everything falls into place, and one can relax and attend to Stein's experiments in these portraits and in *Tender Buttons,* where Gertrude Stein tried in words, like her Cubist friends in their medium, paint, to render the rhythms, sounds, shapes, colors of the external world.

In "Susie Asado" Stein gives us, in one erotically pulsing woman, a nursery rhyme tea hostess, a chirping bird, a Japanese geisha, a Spanish dancer clicking her heels down in a silvery-lit Madrid night spot or "cellar," a witch from MacBeth, an incubus riding a victim, Alice Toklas as Gertrude's "sweetie" or "Sweet T[oklas]" serving tea at 27 rue de Fleurus, and many other versions of all the beckoning desirability of Nature seen as female Being. Here in its entirety, with selective decodings, is "Susie Asado," wherein Stein presents one of her most vivid images of woman as enchantress, yet combines this with a possible philosophic questioning about the nature of matter and even a suggested solution to the problem of human suffering (again, brackets are my hints on a reading, and to aid the reader I have italicized Stein's own words):

Sweet sweet sweet sweet sweet tea.

Susie [Jewsy, choosey, choose me] *Asado* [as I do].

Sweet sweet sweet sweet sweet tea.

Susie Asado [Mikado, the Japanese geisha reference].

A lean on the shoe [the Spanish dancer, perhaps la Argentina] *this means slips* [lips] *slips hers* [slippers].

When the ancient light grey is clean it is yellow, it is a silver ["la Argentina," "the Silver one"] *seller.*

This is a please [request] *this is a please* [appease], *there are the saids to jelly* ["jelly," a black jazz word referring to Jellyroll Morton who played piano in a brothel, was a code word for intercourse in Stein's story in *Three Lives* about a black girl named Melanctha; also here are the jelly and the "he said, she said's" of the ladies' tea party]. *These are the wets* [wets, s*weets*] *these say the sets to leave a crown to Incy* [inky].

Incy is short for incubus.

A pot [pot, spot, belly]. *A pot is a beginning of a rare bit* [rarebit] *of trees* [cheese]. *Trees* [also tease] *tremble, the old vats are in bobbles* [bubbles, bubbling vats of Macbeth's witches, women as creators of magical brews], *bobbles which shade* [spade] *and shove* [shovel] *and render clean* [rend her clear], *render clean must.*

Drink pups [drink ups: kisses, suckings].

Drink pups drink pups [The doubling here, as in other Steinian words and phrases and lines, creates mutual participation] *lease a sash hold, see it shine and a bobolink* [woman as bird, a favorite Stein association] *has pins. It shows a nail* [an "ale" as intoxicating beverage brewed by witches; also an "ail," a pain of sentient desire].

What is a nail ["a nail" can be "an ail," so that Stein asks, "What is an ail?" or "What is a feeling of pain? What is sensation?" These are favorite questions of the Gertrude Stein who studied philosophy with William James. Also, these words may be read in another Steinian way, as making a statement of definition of the word "what," or "matter, substance." Stein tells us in that way of reading the sentence, "'What' is an ail," meaning that the philosophic questions concerning "whatness, substance," are an ail, a painful problem, for us humans].

What is a nail [Stein repeats her phrase, underscoring her point, or forcing us to shift ground, cubistically, to constantly new views of the words' possibilities. Stein could be asking simply about a materially substantial "nail" with a specific function, a pointed object the purpose of which is to join substances together]. *A nail is unison* [union; Stein answers her own question, as she will ultimately in *Tender Buttons,* by combining intellectual meaning and sentient drives in humans and all nature. The answer favors unity, yet there are a plurality of strands being united, not a dualistically conceived mutually-exclusive spirit or matter. The solution is Pragmatic, joyously sensual, celebrating eros and woman]. *Sweet sweet sweet sweet sweet tea* [Stein ends by drinking the witches'

delicious poison offered by her bewitching Alice]. (549)

"Preciosilla" is another rhythmic marvel, ending with the same dark-skinned ("toasted") Susie, Gertrude's "Jewsie" (her pet name for Alice), her "precious silly," again her favorite "cream" dish or dessert after she has told brother Leo, now no longer a member of the household but an unwelcome guest, to "Go":

> . . . diamonds white, diamonds bright, diamonds in the in the light, diamonds light diamonds door diamonds hanging to be four, two four, all before, this bean, lessly, all most, a best, willow, vest, a green guest, guest, go go go go go go, go. Go go. Not guessed. Go go.
>
> Toasted susie is my ice-cream. (551)

The dancer in the companion portrait to "Susie Asado," "Preciosilla," does more than dance. Bait, Preciosilla's clothes are torn off, and she is urged towards a "single mingle," union, in the third paragraph:

> "Bait, bait, tore, tore her clothes toward it, toward a bit to ward a sit, sit down in, in vacant surely lots, a single mingle, bait and wet . . ." (550)

This is obscene, as is the title of "A Sweet Tail (Gypsies)" obscene. And again in "A Sweet Tail" there is depicted what can be construed as an explicit scene of intercourse between two women ("curves"). "Hold in that curl [girl] with a good man," Stein tells herself, assuming the male point of view, and teasing herself and us with all sorts of jokes and puns and meaningful suggestions involving holes in cheese, and pinnings, and a petticoat beloved, whom she urges to "come"; the portrait of the wandering lovers embracing even ends with the "dear noise" of orgasmic bliss:

> *Curves. Hold in the coat* [goat, go at]. . . . *Hold in that curl* [girl] *with a good man. Hold* [hole] *in cheese. . . . A cool brake* ["break" with Leo, again the invisible third party] . . . *Come a little cheese* [*please*]. *Come in to sun with holy pin* [hole leaping] *and have the petticoat to say* [save] *the day . . . a dear noise* [an orgiastic moan, an "Adear" or "Ada(r)" noise, Ada being a code name for Alice in Stein's writing]. (571-74)

Whether as the synecdochic petticoat who brings rosy charm at last to a disgraced Gertrude; or as the "Ada" who inspired Gertrude to write a loving portrayal of herself in Stein's very first portrait; or as the "she" who comes bringing salvation to Gertrude in the revelatory portrait "Two: Gertrude Stein and Her Brother," which documents Gertrude's and brother Leo's falling-out; or as the glittering dancer "Susie Asado" or "Preciosilla"; or as Gertrude's fellow expatriate in Spain, one of the pair of Wandering Jews in "A Sweet Tail (Gypsies)"—in whatever shape or form she assumes, always behind Stein's Sapphic and Sibyllic images of women at the time of *Tender Buttons* and the companion portraits blooms the eros-rose Alice Toklas.

Notes

[1] See *Tender Buttons* in *Selected Writings of Gertrude Stein* ed. by Carl Van Vechten, New York: Random House, 1962, 459-509. An excellent preliminary analysis of *Tender Buttons* can be found in Richard Bridgman's *Gertrude Stein in Pieces.* New York: Oxford University Press, 1970. To understand the thinking of Gertrude Stein, however, one should read William James' *Pragmatism* along with *Tender Buttons,* for the philosophy of James, Stein's teacher at Radcliffe, colors her thought throughout. One of the best articles on *Tender Buttons* is Neal Schmitz's "Gertrude Stein as Post-Modernist: the rhetoric of *Tender Buttons,*" *Journal of Modern Literature,* 3 (1974), 1203-1218.

[2] Herrick's "Delight in Disorder" in The *Literature of England,* 5th ed. 1, Ed. George K. Anderson & William E. Buckler. Chicago: Scott Foresman & Co. 1958. 1007.

> A sweet disorder in the dress
> Kindles in clothes a wantonness. . . .
> A winning wave, deserving note,
> In the tempestuous petticoat. . . .

Like Stein, Herrick is suggestively fond of feasting with cream and other goodies. In "The Wake" (an annual parish festival) he urges his beloved to "Come, Anthea, let us two/Go to feast, as others do," for "Tarts and custards, creams and cakes,/Are the junkets still at wakes . . ." 1005-6.

The inclusion of this note on a poet from English literature gives me the opportunity to point out how deep were Stein's knowledge of, and love for, this literature and the English language itself, which is why I chose to cite a large historical compilation rather than merely a volume of Robert Herrick's poetry. Stein read avidly and constantly in English literature, and the riddles of early English literature, in fact, provide one key to Stein's writing style, as do the classical rhetorical devices found so abundantly in Stein's particular passion, Shakespeare.

Stein's language experiments, it is true, usually follow thoughts metonymically rather than metaphorically, and so she often does the opposite of what medieval allegorists and nineteenth century Symbolists did. Understanding this is one of the keys to understanding Stein's writing. Study of Roman Jakobson's article on Aphasia is helpful here: see "Two Aspects of Language and Two Types of Aphasic Disturbances" in *Fundamentals of Language,* The Hague, 1956, 55-82, and the use to which David Lodge puts this material in "The Language of Modernist Fiction: Metaphor and Metonymy" in *Modernism 1890-1930.* Middlesex, England, Penguin Books Ltd., 1976. In the end, Stein avails herself of a multitude of possibilities of thought and language extension, and to read her one must adopt an elastic approach.

[3] Carl Van Vechten, *Two: Gertrude Stein and Her Brother and Other Early Portraits 1908-1912.* New Haven: Yale University Press, 1951.

[4] Barcelona-Madrid: Editorial Noguer, S.A., 5th ed., 1964, 26.

[5] Van Vechton's *Selected Writings* contains several of the Toklas portraits to which I will refer, "Susie Asado," "Preciosilla," and "A Sweet Tail (Gypsies)."

[6] Bridgman, 138.

[7] Perloff, Marjorie. "Poetry as Word System: The Art of Gertrude Stein." *The Poetics of Indeterminacy.* New Jersey: Princeton University Press, 1981.

[8] Mellow, James R. *Charmed Circle, Gertrude Stein & Company.* New York: Praeger Publishers, 1974.

[9] Steiner, Wendy. *Exact Resemblance to Exact Resemblance.* New Haven: Yale University Press, 1978.

ASPECTS OF MORALITY IN THE MUSIC OF THE MIDDLE AGES

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I

For discipline has no more open pathway to the mind than through the ear.

Boethius, *De institutione musica*

In his classic study of medieval aesthetics, Edgar de Bruyne identifies St. Augustine as the principal source of transmission of Biblically-oriented aesthetics for the Middle Ages.[1] In the fervor of faith following his conversion, Augustine himself formulated several unprecedented aesthetic theories. His abundant writings about music lead to C. J. Perl's conclusion that, for Augustine,

> music communicates a knowledge about God, indeed the very knowing of God, and moreover, as becomes clear from the manner of expression, it mediates this knowledge more clearly, more directly, than could words by themselves.[2]

This "very knowing of God" is a process involving the interrelation of sound and time, and the regard of the mind toward that interrelation. Thus does the regard—the modes of perception and response—in turn constitute a significant measure of the morality of any culture; the following is a study of that regard in the Middle Ages.

The numerical aspect is the most well-known. The Greek view of the relation between music and numbers, attested to by numerous writers of antiquity,[3] can be seen through Lewis Rowell's neat summation:

> To the Greek mind, the experience of musical rhythm was an outward manifestation of man's biological rhythms and the proper proportions of the world of forms he inhabited. For rhythm to work its effects upon man, it must be intelligible to his sense perception . . . , and his apprehension of rhythms required him to form mental images that resembled the sounds he perceived. In this way he was brought into tune with the world of external forms in a totally balanced, harmonious, mental and physical state.[4]

The mental imagery was number and proportion, as Pythagoras had discovered. But it should be emphasized that rhythm was meant not only as pulse and metre. To the Greeks, music was primarily verse, and rhythm connected music with language.[5]

This aesthetic, "mathematics incarnate in physical form,"[6] was transmitted to the Middle Ages through the enormous influence of the *Timaeus* of Plato (specifically, in the commentary on it written in the 3rd century by Chalcidius) and—more importantly for music—through the writings of Boethius. Boethius asserted the superiority of the speculative over the practical in music—the superiority of *musica disciplina,* as it was by this time known, over *musica sonora.* This division was partly the result of an attempt by Boethius' contemporary Cassiodorus to distinguish the liberal arts (numerous in Greek antiquity, reduced to seven by Martianus Capella in his *Marriage of Mercury and Philology*) by designating those dealing with human affairs (the *trivium* of grammar, logic or dialectic, and rhetoric) as *artes,* the remainder (the numerically-related *quadrivium* of arithmetic, geometry, music and astronomy) as *disciplinae.* All of the *artes liberales* were in antiquity originally known as *propaideumata,* and affinities had

existed between them.[7] Indeed, Boethius himself, in his last work, has Philosophy call upon:

> . . . the sweet persuasiveness of rhetoric, which can only be kept on the right path if it does not swerve from our precepts, and if it harmonizes, now in a lighter, now in a graver mood with the music native to our halls.[8]

But there is little doubt that, in Cassiodorus' terminology, the *trivium* was seen as inferior, *artes triviales*—primarily utilitarian and "wholly propaedeutic" themselves to the abstract speculation afforded by the *quadrivium.*[9]

Boethius, through a tripartite division of *musica* into *mundana* (the music of the spheres), *humana* (that of both the body and the soul), and *instrumentalis* (the sound), reinforced this hierarchy, elevating it (perhaps unintentionally) to an aesthetic principle that dominates both the theory and aesthetics of music throughout the Middle Ages. The appeal was to the mind, to *ratio,* through number and the properties of number, through the medieval belief that the mind could perceive images of a Divine Order in an otherwise terrifying and meaningless universe. These images (and all things and ideas were, in the Timaean account, only images: diversities proceeding from an essential unity) could be subjected to speculation (from *speculum,* mirror) by deducing numerical proportions in them—a wholly interior activity of the intellect—and subsequently reflect some aspect of nature's manner of operation within Divine Order. The *speculum* showed how things act when they thus belong to a type.

However, problems arise when we try to determine any kind of comprehensive correspondence between this view of music and the influence it had on both the thought and action of the Middle Ages. "Medieval theory reduced the idea of beauty to that of perfection, proportion, and splendor," wrote Huizinga.[10] It is not at all certain that medieval practice did so. Huizinga goes on,

> many treatises on the aesthetics of music were written, but these treatises, constructed according to the musical theories of antiquity, which were no longer understood, teach us little about the way in which the men of the Middle Ages really enjoyed music . . .[11]

We need not acquiesce in Huizinga's harsh conclusion that "substituting for beauty the notions of measure, order, and appropriateness offered a very defective explanation of it,"[12] in order to see one thing clearly: the aesthetic record is but part of the reality of the medieval musical experience.

One problem is that the aesthetic record reflects, in the main, the concerns of the Church: "Musical sensation was immediately absorbed in religious feeling."[13] This originated with Augustine, himself acutely sensitive to the aural enticement of music, of the "peril of pleasure."

> Yet when it befalls me to be more moved with the voice than the words sung, I confess to have sinned penally, and then had rather not hear music.[14]

Augustine's solution to this moral dilemma was to make of music a metaphor for communication with God. In the Middle Ages, the emotions were seen as the effects of the senses on the mind, and the senses were lowest in the structure of the mental faculties, to be superintended by imagination, reason, and intelligence. And Denis the Carthusian, also aware of the emotional effects of music, was reduced, in an age of increasing Christian domination, to describing them in terms of sin.[15] Christian doctrine was more secure when it could absorb *musica sonora* into *musica disciplina.*

The Greeks had done this too. Sachs wrote that the scholars of antiquity attempted to classify melodies (which originated in improvisation, with little or no thought given to such representations as vibration ratios), calling this classification "a sham legalization of lawlessness,"[16] one that persisted into the Middle Ages, in the form of the church modes. These modes were de-

signed to house pre-existing chant melodies (which "in notation look so neat and equal-tempered"), and all modes relied on the octave to delineate range; the melodies themselves "had no octave at all or at best one that served in a passing capacity."[17]

But doctrine is one thing, devotion another. And if Carrolly Erickson is correct in maintaining that religious devotion in the Middle Ages "followed a rhythm of its own, and did not correspond in any direct way to the maturing of ecclesiastical institutions or to the political victories or defeats of the church,"[18] the capacity of the written record to account for the relation of music to morality is even further reduced.

Another problem quickly follows: the overwhelming proportion of extant medieval art is Church art. In fact, *musica sacra* is all that survives of early medieval music, although Sachs asserted that secular song was both socially and politically more important in the daily life of the time.[19] So the question finally turns into an old one: how much do the treatises have to do with the moral concepts and conduct of their time? If a connection existed between music and morality, even a unity such as obtained between morality and science (through the links of grammar and poetry), it must be looked for beyond the realm of number, in other modes through which the mind perceives and represents the world.

II

Sight is often deceived, hearing serves as guarantee.

Ambrose of Milan, *Commentary on St. Luke*

Two historical events unique to the Middle Ages can help bring the problems into focus. One event was musical: the advent of polyphony in a musical tradition which until the ninth century had been exclusively monodic. "The invention of polyphony was undoubtedly the most significant event in the history of Western music," Richard Hoppin flatly and rightly declares.[20]

The other event, which preceded polyphony (indeed, made it possible), was the advent of musical notation. As part of a larger process involving a gradual shift in the orientation of the medieval mind from a preliterate, predominantly oral-aural mentality to a predominantly literate-visualist one, this phenomenon was cultural in a more comprehensive way. Both can be examined in the light of the other great theory of music handed down by the Greeks, the doctrine of *ethos,* described by Aristotle in the *Politics:*

> . . . melodies themselves . . . do contain imitations of character . . . with the rhythms the situation is the same. . . . From all this it is clear that music is capable of creating a particular quality of character in the soul. . . . There also seems to be a close relation of some sort between the soul and *harmoniai* and rhythms, which is why many wise men say either that the soul is a *harmonia* or that it contains one.[21]

If melodies imitate character, notation imitates melodies; sight imitates sound. What was the origin of music-writing?

The medieval belief, persistent in subsequent eras, was formed by the Gregorian legend during the Carolingian Renaissance. Leo Treitler has facilitated understanding how this legend succeeded in its purpose, by drawing a parallel with the modern view of musical invention and transmission:

> A corpus of music has originated in a certain time and place and through the agency of a particular person [in the one view, Gregory I receiving chant melodies from the dove; in the other, the composer writing under the guidance of divine inspiration]. At the

> moment of its origin it is written down. The repertory has spread through a transmission that has left a multiplicity of versions [in the one view, varying *mss.* of the same chant melody; in the other, differing copies and editions of the same work]. After some time it is observed that the versions do not agree with one another. This is interpreted as the consequence of a process of corruption, and an editorial enterprise is undertaken to restore and establish the original. As standard for the enterprise a source closest to the point of origin, an original version is sought [in the one view, through the efforts of Charlemagne and Alcuin, in the other, through the efforts of the *Urtextherausgeber*].[22]

But Treitler argues that the original purpose of music-writing was descriptive. The earliest extant examples of proto-notation appear to consist of punctuation signs borrowed from script writing placed in relation to the chant text so as to show the singer where to pause, lengthen a word or syllable, inflect the voice, etc., all in relation to a previously known melody. They were visual aids to the memory of sounds, supporting the "performance of a text already known and accepted." The later diagrammatic notation of the anonymous *musica enchiriadis* and the *musica disciplina* of Aurelian of Reôme, both dating from the ninth century, display evidence of the earliest attempts to actually *picture* the sound-space of a melody by placing both the notation symbol (the neume) and the text syllable at points in space corresponding to the pitch location of the melody.[23]

The Gregorian legend was a tool of policy in the ecclesiastical history of the Holy Roman Empire, a tool used in the Carolingian literacy campaign. "The script culture that the Carolingians created is the general background against which the foundation of a notational practice becomes understandable."[24] The campaign itself was theological, the liberal arts now serving *in toto* as propaedeutic to the understanding of the Scriptures. In a realm whose governing was obstructed by numerous vernacular varieties of Latin, to say nothing of native Germanic, Frankish, Slavic, even non-Indo-European dialects, a uniform and standard repertory of chant melodies offered a persuasive, even seductive means to solve the political problem of polyglottism. Codifying the melodies by encasing them in the eight church modes narrowed the tonal unorthodoxy. The establishment of standardized Latin as the language of the Roman Church was brought about in large part through music-writing, a process that made its first appearances about fifty years after the beginning of Charlemagne's campaign. "The occidental notational system is *par excellence* a control system," wrote Charles Seeger, a statement that is applicable on several levels, musical, cultural, political—and thus moral.[25]

But control is not the end of the matter. The evolution of the word from symbol to fact (the former an ancient, even prehistoric awareness inherited by the Middle Ages, the latter wholly foreign to the medieval mind, familiar enough to the modern) can be found condensed in subsequent developments of medieval music notation:

> The idea of a control system is just the right way to think about the role of notation in an oral performing tradition. Yet there is a point beyond which controls operate so closely and so constantly that the notation becomes in actuality a system of direct representation rather than of controls. When it functions that way, notation has realized an ideal that was expressed by writers on music . . . from Carolingian times to the thirteenth century—for [*sic*] explicit notations that could be read off by performers coming to them cold, for prescriptive rather than descriptive notations. . . . When writing is conceived in the light of a complete equivalence between uttered [or sung] sound and written sign it can function as an autonomous mode of direct communication, and no longer just as an aid to memory. . . .[26]

Polyphony had undoubtedly been in the air. It should be emphasized at this point

that it is evident, from their manner of discussion, that authors of the early treatises on polyphony—Regino of Prüm, Hucbald, and the anonymous author(s) of the *musica* and *scholia enchiriadis*—were describing something that had existed in practice for some time. Poor ensemble is as eternal as Divine Order, and in a group performance of monody this heterophony, to use the modern euphemism, must frequently have hinted at the possibilities inherent in intentional divergence. The medieval belief that some of the mysteries of nature could not be understood by the intellect alone is reflected in a question asked in the *musica enchiriadis:* why do certain tones sound well in combination, while others do not? A speculative answer is offered, one which, in its deference to the past, typifies the medieval spirit and connects both parts of the Greek tradition:

> There are several writings of the ancients in which it is convincingly shown . . . that the same numerical proportions by which different tones sound together in consonance also determine the way of life, the behavior of the human body, and the harmony of the universe.[27]

Now, Bukofzer could say, "polyphony deserves to be called the image of universal harmony rather than monody."[28]

Polyphony—the deliberate simultanaiety of two or more musical lines—signalled an incorporation of the plurality of the world of sound into an unprecedentedly complex and powerful symbolic of harmony. The ancient belief in this symbolic became audible. Horizontal and vertical truth, never regarded by the Middle Ages as contradictory or dualistic, could be heard. "The discipline of music," Cassiodorus had written earlier,

> is diffused through all the actions of our life. . . . Musical science is the discipline which treats of numbers in their relation to those things which are found in sounds.[29]

Polyphony was not just a new dimension to this, but a fusion: *musica disciplina* become *musica sonora.*

Or confusion? In medieval grammatical and philosophical usage, one sometimes meant the other, i.e., con/fusion seen as "coming together" or "intertwining." Polyphony could appeal to the imagination, through the construction of images (here, consonances) reflecting order, and to the intellect—*ratio*—through numerical porportion. But its impact on the aural sense was the most perplexing and the most dangerous. The medieval concept of the psyche was of a tripartite mind: "The recollective faculty is placed at the rear [of the head], the speculative power is foremost, and reason exercises its power at the center."[30] Sound infiltrates the first two on its way to the memory, from which it is then often impossible to eradicate. Polyphonic sounds in the memory could be activated—relocated from sense outward through reason to speculation, where they could reflect the harmony of the mind with the external world from which they came. As the temptation grew to make polyphony more complex and sophisticated, so did ideas of order, ideas of music and time.

III

> Music reveals, beyond the manifestations of the senses,
> the inner will that arouses them.
>
> Schopenhauer, *The World as Will and Idea*

It is useful to here reiterate that the invention and performance of early medieval music were oral, and relied "on memory, tradition, improvisation, and non-intellectualism."[31] The foundations of music, then, were not sacred/political—the Church

merely appropriated practice—but sacred/ societal, or more accurately, sacred/ communal; the heritage stems from the tribal era,[32] a world of sound and memory but not yet of order. Noise, writes Jacques Attali, is a source of power. "*It is sounds and their arrangements that fashion societies.* With noise is born disorder and its opposite: the world."[33] The evolution of order parallels the development of consciousness, and here we must briefly turn to the affinities between music and rhetoric.

> All human culture was . . . initially rhetorical in the sense that before the introduction of writing all culture was oral. This means not merely that all verbal communication—there are obviously other kinds of communication—was oral, effectively limited to sound, but also that the economy of thought was oral.

So writes Walter Ong in his essay on Rhetoric and the Origins of Consciousness.[34] This economy is a result of the nature of sound. It is not just that sound was an essential means of communication and survival in oral cultures. Sound is unique among the senses in that it is polysemous. Its signals embody multiple meanings, are susceptible to multiple interpretations, because sound, unlike the signals to the other senses, presents itself not in sequence but in simultaneity. Furthermore, since "hearing can not eliminate selectively—there is no aural equivalent of averting one's face or eyes,"[35] of spitting out, of withdrawing touch—sound is inescapable.

Rather than trying to make distinctions, rhetoric unifies, by working "through the imagination, which euphemizes actuality through hyperbole and antithesis."[36] In music, actualities are hyperbolized as well. The perception of sustained and repeated sounds, both macro- and microcosmic, were fashioned into images of order. This order, rhythm, became sacred when one could submit to it in return for protection (from the threat represented in the multiplicity of the sound-world) and security (which became belief and eventually, knowledge). In this way music is linked as semiotics with the rhetoric Ong claims "clearly occupies an intermediary stage between the unconscious and the conscious."[37]

Sachs provocatively suggested that rhythm "played no essential role in the music of ancient and medieval Europe," substantiating this by pointing to the almost total absence of percussion instruments in both Antiquity and the Middle Ages. And Johannes de Grocheo, writing ca. 1300, stated that no monody (sacred or secular) was *ita precise mensurata.*[38] Rhythm was a necessity only in terms of the dance. But dance, being of the flesh, was inferior to song, which, carrying the Word, was at least potentially of the spirit.

Nonetheless, "the major new preoccupation of composers and theorists of music in the twelfth and thirteenth centuries [was] the coordination of time, a newly recognized dimension for musical ordering," writes Treitler. "The regulation of two or more voices in respect of both pitch and time created a new level of complexity. It called for decisions to be made in advance"—decisions now in the hands of the composer—"and communicated, through notation"—now a set of instructions which restricted improvisation and were to become more and more specific—"to performers. The effect of this was a tendency to fix music, both conceptually"—ideas of what music was and what it could be used for—"and notationally—not for canonical reasons"—these were beginning to lose, ever so gradually, their validity—"or initially for aesthetic ones"—these would be noticed later—"but primarily for practical purposes."[39]

But why regulation, and why the tendency to fix? The Timaean universe created by God was one of perfect, perpetual, harmonious, circular motion. If in the medieval mind morality was a process of subservience, of submission, of self-imposition, why the growing need to control the external world of sound? Perhaps it was not to facilitate

finding one's place in the Divine Plan, not another allegory of world harmony, but a symptom of the soul in disharmony.

> The major change in the mind of man . . . which distinguishes the Middle Ages from antiquity and which caused the fundamental reconstruction of man's basic concepts and attitudes is centered around the act of redirecting the path of causality.[40]

Redirection began with the birth of Christianity, "God's personal entry into history,"[41] and the consequent concept of linear time. This concept generated the medieval distinction between vertical and horizontal truth, allegory and typology, and originated with Augustine. Augustine presented his discovery of the relation of time to memory in the eleventh chapter of the *Confessions:*

> I am about to repeat a Psalm that I know. Before I begin, my expectation is extended over the whole; but when I have begun, how much soever of it I shall separate off into the past, is extended along my memory; thus the life of this action of mine is divided between my memory as to what I have repeated, and expectation as to what I am about to repeat; but "consideration" is present with me, that through it what was future, may be conveyed over, so as to become past. Which the more it is done again and again, so much the more the expectation being shortened, is the memory enlarged; till the whole expectation be at length exhausted, when that whole action being ended, shall have passed into memory. And this which takes place in the whole Psalm, the same takes place in each several portion of it, and each several syllable; the same holds in that larger action, whereof this Psalm may be a part; the same holds in the whole life of man, whereof all the actions of man are parts; the same holds through the whole age of the sons of men, whereof all the lives of men are parts.[42]

In chapter 12, Augustine distinguishes between sound and music; "a tune is a formed sound." Time is the *sine qua non* of one becoming the other:

> . . . for we do not first in time utter formless sounds without singing, and subsequently adapt or fashion them into the form of a chant, as wood or silver, whereof a chest or vessel is fashioned. For such materials do by time also precede the forms of the things made of them, but in singing it is not so; for when it is sung, its sound is heard; for there is not first a formless sound, which is afterwards formed into a chant. For each sound, so soon as made, passeth away, nor canst thou find ought to recall, and by art to compose. So then the chant is concentrated in its sound.[43]

Memory of events creates the awareness of time. Time in turn is the vehicle of sound and music. For sound to become music, it must do so at the time it exists; it cannot be refashioned. *It must be fashioned entirely within the present, its own presence.* "But the present, should it always be present, and never pass into time past, verily it should not be time, but eternity."[44] Music is thus an intermittent glimpse (hearing, really) of eternity, passing in and out of existence with time. But why is the present not always present?

Here we may turn to Augustine's earlier *De musica libra sex,* to the final book, in comparison with which the first five were "child's play."[45] We return to the realm of *musica speculativa,* of numerical proportion. Augustine posits a level of numbers, and traces them upwards, each level evoking a new layer of consciousness: hearing through the reacting numbers, recognition through the memorial, pronunciation (singing?) through the advancing, delight through the judicial, appraisal through "still others, and in accordance with these more hidden numbers we bring another judgment on this delight, a kind of judgment on the judicial numbers."[46] Then we find a new, Augustinian insight:

> And, if we have been right in our judgment, the very sense of delight could not have been favorable to equal intervals and rejected perturbed ones, unless it itself were imbued with numbers; then, too, the reason laid upon

> this delight cannot at all judge of the numbers it has under it, without more powerful numbers.[47]

This, O'Connell believes, implies that reacting numbers—embodying sound—are at the bottom of a cascade of numbers proceeding from God, and that the even deeper implication, therefore, "is that the intelligible is, quite literally, a 'remembered' world, one of which the soul is literally reminded, to which it needs to be recalled."[48]

That the experience of time is a reflection of the soul's fall from grace is an idea that recurs in the *Confessions*. After discussing the memorial-temporal relation and applying it to the whole life of mankind, Augustine adds, "but because Thy loving-kindness is better than all lives, behold, my life is but a distraction."[49]

Plotinus had written that the soul passes from an original, timeless state into motion, and that "time moved with it."[50] Being in time means motion in time. It is a fallen condition; we have been "sewn into the order" of time as a consequence.[51] In the Augustinian meaning, the original sin was tripartite: through 1) curiosity, the soul was seduced into 2) "carnal concupiscence," which, by detouring the soul's attention to the body, results in 3) neglect of the soul's true master, God.[52] Original sin was the result of what Plotinus called the element of "restlessly active nature" contained in the soul;[53] the world of time is the punishment for that sin by prolonging it. The world we perceive through the lower levels of numbers is a product of our morality.[54]

But morality, as the Middle Ages knew, is in use, specificially, in *bene utendo*. The mind could be freed from time by using time. Had human nature remained obedient, it "should have no such connections as are contingent on birth and death."[55] The implication could not be more clear: time and sin are coeternal. Through the use of time to transcend time, music could communicate the very knowing of God. Truth, the Middle Ages also knew, depended on the accuracy of reproduction of an idea.

Notes

[1] de Bruyne, Edgar, *The Esthetics of the Middle Ages,* trans. E. B. Hennessy. New York: Frederick Ungar, 1969. p.44.

[2] Perl, Carl Johann, "Augustine and Music," *Musical Quarterly,* XLI, 4 (October 1955), 507.

[3] Strunk, Oliver, *Source Readings in Music History.* New York: W. W. Norton and Co., 1950. pp. 3-56.

[4] Rowell, Lewis, "Time in the Musical Consciousness of Old High Civilizations—East and West," in *The Study of Time,* III, ed. J. T. Fraser, N. Lawrence and D. Park. New York: Springer-Verlag (1978) 606.

[5] Georgiades, Thrasybulos, *Music and Language.* Cambridge: Cambridge University Press, 1982. p. 4.

[6] de Bruyne, *op. cit,* p. 48.

[7] Kresteff, Assen D., "*Musica Disciplina* and *Musica Sonora,*" Journal of Research in Music Education, X, 1 (Spring, 1962), 13.

[8] Boethius, *The Consolation of Philosophy,* trans. S. J. Trester. Cambridge: Cambridge University Press, 1923. 21-25.

[9] Kresteff, p. 18.

[10] Huizinga, J. *The Waning of the Middle Ages.* Garden City: Doubleday and Co., n.d. (originally publ. 1924) p. 267.

[11] *ibid.,* p. 268.

[12] *ibid.,* p. 269.

[13] *ibid.,* p. 267.

[14] Augustine, *Confessions,* trans. E. B. Pusey. New York: Pocket Books, 1951. p. 202.

[15] Huizinga, pp. 267-68.

[16] Sachs, Curt, "Primitive and Medieval Music: A Parallel," *Journal of the American Musicological Society,* XIII (1960), 44.

[17] *ibid.,* p. 46.

[18] Erickson, Carrolly, *The Medieval Vision.* New York: Oxford University Press, 1976. p. 66.

[19] Ibid., p. 43. For another viewpoint on the relations between Church, music, and medieval life, see Huizinga, pp. 250-51.

[20] Hoppin, Richard, *Medieval Music.* New York: W. W. Norton and Co., 1978. p. 186.

[21] Barker, Andrew, ed., *Greek Musical Writings,* v.I. Cambridge: Cambridge University Press, 1984. pp. 175-76. Elsewhere, Barker elaborates Sach's issue of the "sham legalization of lawlessness:" "The *harmoniai* are treated as theoretical abstractions of melodic sequences occurring in actual tunes . . . rather than as scalar structures consciously adopted by the musicians themselves to form a predetermined framework for their melodies." (*ibid.,* p. 281n)

[22] Treitler, Leo, "Homer and Gregory: The Trans-

mission of Epic Poetry and Plainchant," *Musical Quarterly*, LX, 3 (July 1974), 341-42.

[23] Treitler, *ibid.*, p. 342, and "Reading and Singing: on the genesis of occidental music-writing," *Early Music History* 4, ed. Iain Fenlon, Cambridge: Cambridge University Press, 1984, pp. 141-53 and *passim.* Note especially, in the latter article, Treitler's observation that the concept of music as language is a "topos that runs through the medieval theoretical literature as the fundamental principle of musical structure." (p. 146)

[24] _____, "Reading and Singing," p. 141.

[25] *Dictionary of Folklore, Mythology, and Legend* (1972), pp. 825-29, cited in Treitler, "Oral, Written, and Literate Process in the Transmission of Medieval Music," *Speculum,* 56, 3 (1981) 488.

[26] Treitler, "Oral, Written, and Literate Process in the transmission of Medieval Music," *Speculum,* 56, 3 (1981), pp. 489-90.

[27] *musica enchiriadis,* ed. Martin Gerbert in *Scriptores ecclesiastici de musica medii aevi* (St. Blasien, 1784, I, 172), cited in Bukofzer, "Speculative Thinking in Medieval Music," *Speculum,* XVII, 2 (April 1942) 174.

[28] Bukofzer, *ibid.*, p. 174.

[29] Strunk, p. 88. Compare this with the definition proposed by Webern, paraphrasing Goethe: "Music is natural law related to the sense of hearing." (*The Path to the New Music,* Bryn Mawr, 1963, p. 11)

[30] Bernardus Silvestris, *Cosmographia,* trans. W. Wetherbee. New York: Columbia University Press, 1973. p. 123.

[31] Sachs, p. 44.

[32] *ibid.*

[33] Attali, Jacques, *Noise,* trans. B. Massumi. Minneapolis: University of Minnesota Press, 1985. p. 6. On noise as disorder, cf. Kubler, George, *The Shape of Time,* New Haven: Yale University Press, 1962. p. 20. "All substantial signals can be regarded both as transmission and as initial commotions."

[34] Ong, Walter, S. J. *Rhetoric, Romance, and Technology*, Ithaca: Cornell University Press, 1971. p. 2.

[35] Ong, Walter, S. J. *The Presence of the Word,* New Haven: Yale University Press, 1967, p. 130.

[36] Gilbert Durand, *Les Structures anthropologiques de l'imaginaire* (Paris, 1960), cited in Ong, *Rhetoric, Romance, and Technology*, p. 13.

[37] Ong, *ibid.* pp. 11-12.

[38] Sachs, p. 46.

[39] Treitler, "Oral, Written, and Literate Process," pp. 490-91.

[40] Kresteff, p. 20.

[41] Ong, *The Presence of the Word,* p. 11.

[42] Augustine, pp. 236-37.

[43] *ibid.*, pp. 264-65.

[44] *ibid.*, p. 224.

[45] *De Musica,* VI, cited in O'Connell, Robert J., S.J. *Art and the Christian Intelligence in St. Augustine.* Cambridge: Harvard University Press, 1978. p. 66.

[46] *De Musica,* VI, cited in Perl, p. 503.

[47] *ibid.*, p. 504.

[48] O'Connell, pp. 66-68, 70-71.

[49] Augustine, p. 237.

[50] *Ennead,* III, 7, "On Eternity and Time," cited in O'Connell, p. 79.

[51] *De Musica,* VI, 30, cited in O'Connell, p. 75.

[52] *De Musica,* IV, *op. cit.*, p. 74.

[53] *Ennead, op. cit.*

[54] O'Connell, p. 84.

[55] *De Vera Religione,* 88. cited in O'Connell, p. 89.

POPULATION ECOLOGY OF ROCK DOVES IN A SMALL CITY

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Abstract:

We studied population dynamics of rock doves *(Columba livia)* in Stevens Point, Wisconsin from June 1976 through September 1977. A relatively stationary population of about 900 rock doves used 112 roosting sites within the city. Eight communal roosts contained 70% of the population. Rock doves nesting in communal roosts may be more productive than pairs nesting on houses. Annual increment was estimated at 43%, but mortality and dispersal rates were balancing. Rock doves were relatively healthy; the only zoonosis was *Chlamydia,* found in 21% of 103 blood samples. Rock doves were considered a nuisance by 37% of 1,299 households interviewed. The rock dove population should be managed by reducing the number of large roosts and adopting procedures to reduce food sources.

INTRODUCTION

Rock doves (feral pigeons) can be found in almost every urban area in North America, and are controversial in most. Large concentrations can cause health hazards (Scott 1964), noise, aircraft threats (Solman 1974, and economic loss (Murton et al. 1972*a*). By contrast, they are beneficial scavengers, and the only large wild bird readily viewed in downtown areas (Scott 1961). Most efforts to reduce the population size of rock doves have temporary effect until the population recovers through recruitment (Scott 1961, Murton et al. 1972*a*). This study was initiated in response to complaints of nuisance rock doves. It examines recruitment, nesting locations, movement patterns to food and water, and nuisance status of rock doves in a typical midwestern city to identify weak ecological links which might be exploited for population control.

STUDY AREA

The city of Stevens Point in Portage County, central Wisconsin, contains 24,000 people in an area of 29 km^2. Most houses and business establishments within the inner core of the city were built between 1870 and 1930. Architectural designs include Italianate, Victorian, Neoclassical Revival, Prairie, and Southwest Bungalow. Churches are of the Gothic style with domes showing Polish influence. Suitable rock dove roosting and nesting habitat results from the intricate ornamentation, complex roof structure, gables, and long over-hanging eaves of buildings. Such architecture is typical of urban areas in Wisconsin. Railroad cars transporting grain are subject to spillage, and are emptied and washed in Stevens Point, providing rock doves with food. Winters are severe, averaging 74 days/year when the maximum temperature is 0°C or below. Stevens Point averages 122 cm of snowfall/year.

METHODS

From June 1976 through September 1977 daily movements were observed with spotting scope and binoculars from high vantage points. Nesting and roosting-site suitability

was identified by the number of rock doves using the site, amount of overhead cover, and nesting success after a season of observation. Productivity of 15 house nest sites and 2 church communal nest sites was compared during summer 1977.

Rock doves were live-trapped with a wood frame drop net triggered by a pull-string, a wood frame top-slotted drop-in trap, and with a fish landing net used in the roosts at night. Doves were banded, and marked with color-coded patagial tags and spray paint on wings to identify individuals and flocks. Population density was identified by 2 types of monthly observations: doves were counted in their roosting areas by night, and at feeding and loafing sites by day. Flock counts were most effective during winter, when rock doves concentrated daily at loafing areas, and few were on nests. Photographs were used to facilitate counts of large flocks. At intervals each month, daily observations of movement patterns to food and water were made from roofs of various buildings within the city, and on ground near roosting, nesting, staging, feeding, watering, and loafing areas. During winter months, local rural pigeon roosts were surveyed with binoculars for marked dispersed urban rock doves. Doves loaf on roofs of silos, barns, and other buildings, especially on clear, cold winter days. Requests were made through the local newspaper for sightings of marked rock doves outside of Stevens Point.

Blood samples and cloacal swabs were collected monthly and analyzed at cooperating laboratories for the following zoonoses and blood parasites: influenza, parainfluenza, Newcastle disease, western equine encephalitis, eastern equine encephalitis, St. Louis equine encephalitis, California encephalitis, chlamydiosis, histoplasmosis, blastomycosis, cryptococcosis, salmonella, *Haemoproteus, Leucocytozoan, Plasmodium.* Blood was obtained through heart puncture with a 22 guage, 3.8-cm needle used with a 5 cc vacutainer. All rock doves were returned alive to the population.

Results

Nesting and Roosting Sites.—Most of the 112 nesting locations found were in the central part of the city where the older houses and buildings are located. Eight large (<30 birds) nest sites accounted for 70% of Stevens Point's rock doves. These large nest sites were higher than 6 m, protected from the weather, and inaccessible to humans and other animals.

Of 970 rock doves, 30% nested on 92 houses. These were older houses with eaves, dormers, roof support brackets, or other structures of a characteristic height, shape, depth, and overhead coverage lacking on newer houses in the city. A count of 502 houses with apparently suitable nesting habitat in the community indicated that 12-15% of available nesting structures were being used. Rock doves roosted mostly under the dormer eaves and on the brackets. Single pairs of rock doves occupied the roost/nest niches of houses. Additional rock doves roosting at the same site usually were the pair's most recent progeny. The mean height from the ground of a house roost was

Table 1. Results of a survey of all Stevens Point households with rock doves where the question, "Do you believe pigeons are a nuisance?" was asked.

Households interviewed ($N = 1299$)	N	%
Nuisance	475	36.6
Not nuisance	750	57.7
Undecided	74	5.7
Total	1299	
Answers from people who had encounters with rock doves on their property.		
Nuisance	59	50.0
Not nuisance	44	37.3
Undecided	15	12.7
Total	118	
Answers from people who did not have encounters.		
Nuisance	416	35.2
Not nuisance	706	59.8
Undecided	59	5.0
Total	1181	

6.5 m. Selection by rock doves of aspect ($N=107$) showed no distinct pattern, although they seemed to avoid west, north, and south sides of houses.

A complete house-to-house survey of the central (older) section of Stevens Point, where rock doves occurred, was conducted for locations of pigeon activity and to determine if people considered rock doves a nuisance. Of 1,299 people sampled, 58% thought rock doves were not a nuisance (Table 1).

Production.—We banded, marked, and released 284 rock doves, including 56 juveniles, with patagial markers. We monitored 281 nests (246 nests at 2 churches, 30 nests on 15 houses, 3 nests in trees, 2 nests at a school).

During April-August 1977, 86% ($N=70$) of the house-nesting rock doves nested on the 15 houses studied intensively. House-nesting rock doves usually did not renest (Table 2) or nest at all during a 5-month period from late fall to early spring. Hatching success of 281 nests observed throughout the city was 71%. From 544 eggs laid, 288 rock doves (53%) fledged. During April-August 1977, 70 house-nesting rock doves fledged 37 young, or 53% of their population, compared to 104% for the 2 churches studied (Table 2). The number of young produced was different ($P<0.01$, $x^2=9.47$,

TABLE 2. Productivity of communal nest sites versus house sites in Stevens Point, WI, 1977.

		Communal		
Total	*Houses (N=15)*	*St. Stansilaus Church*	*St. Joseph Church*	*Combined*
N rock doves	70	65	46	111
N Nests[a]	30	54	31	85
N fledged	37	67	48	115
Fledglings/nest	1.23	1.24	1.55	1.35

[a] Includes renests.

TABLE 3. Estimated productivity and annual increment for the Stevens Point, WI, pigeon population, 1977.

Roost site	N *Roosting*[a]	N *nesting*	N *nests*	*Total*[d] *young/year*
St. Stanislaus[b]	100	66	33	134
St. Joseph[b]	75	46	23	93
Shippy Store[b]	100	24	12	49
St. Stephen[b]	50	20	10	41
Fox Theater[b]	100	10	5	20
Dam	50	—	—	—
Old Main[c]	75	30	15	37
Black Bridge[c]	50	30	15	37
Houses[c]	291	210	105	258
Total	891	436	218	669

[a] Average *N* pigeons at roost site.
[b] Communal roost productivity value of 1.35 fledglings/nest and 3 nests/year.
[c] House roost productivity value of 1.23 fledglings/nest and 2 nests/year.
[d] Total young = nests x productivity value (b or c).

$$\text{Annual Increment} = \frac{N_T - N_O}{N_T} = \frac{(891+669)-891}{1560} = 43\%$$

df = 2) between the 15 house sites studied and the communal nest sites in the 2 churches, but the number of fledglings/nest was similar between 1 of the churches and the houses (Table 2). On the 15 houses studied intensively, at least 57% of the rock doves were non-breeders (Table 2); on the 92 houses with rock doves, at least 28% of the rock doves were non-breeders (Table 3). In the 2 communal nest sites studied intensively, at least 28% of the rock doves were non-breeders (Table 2); in the 5 communal nest sites, at least 61% of the rock doves were non-breeders (Table 3). Overall, 51% of the rock doves in Stevens Point were non-breeders in 1977 (Table 3).

Although more nests were produced in the 1st nest attempt, nest success reached 71% with the 3rd nest attempt (Table 4), of which 68% were started in June and July. First nest attempts of the year were 81% successful during April through July 1977. No eggs were laid in December and January and no young fledged in February.

The rock dove population was relatively stable, fluctuating between 850 and 1,030 birds from May 1976 to August 1977, or 76-89 rock doves/km^2 (Table 5). In August 1976, 66% of the population of rock doves (N = 910) lived in communal nest sites, 32% on houses, and 2% on other buildings. A population decline in March 1977 followed a very cold winter. A decline in May 1977 resulted from more rock doves (140) than usual being shot by the Stevens Point Police Department in response to complaints; the effect on nesting is unknown.

Mortality and Dispersal.—We estimated an annual increment of 43% for the rock dove population by expanding productivity values obtained from known church and house nest sites to the other nest sites in Stevens Point (Table 3). From January through August 1977, the mortality of 155 rock doves was accounted for. With an estimated production of 670 rock doves, 515 rock doves remained unaccounted for. Although the study period did not cover the last 4 months of 1977, data from the same period in 1976 indicated that little mortality occurred. We found only 8 dead rock doves from September to December 1976. Much of this mortality probably was caused by human-related activities (i.e., shooting, trapping, road-kills). Such mortality was difficult to monitor because some people shoot and trapped rock doves secretly, and road-kills often were picked up immediately by the city sanitation crew. Dispersal, perhaps to rural roosts, may have been high. No marked rock doves were observed during 3 visits to adjacent rural roosts in winter

TABLE 4. Nest attempts of 64 pairs of rock doves at 2 churches and the fate of their 160 nests, Stevens Point, WI, January-September 1977.

	N *nest attempts*					
	1	*2*	*3*	*4*	*5*	*6*
N nests	64	41	28	20	6	1
Nest mortality[a]	15	12	7	8	3	1
N successful[b]	36	28	20	10	2	0
N unsuccessful	28	13	8	10	4	1
% success	56.3	68.3	71.4	50.0	33.3	0

[a] Nest mortality = number of nests abandoned or destroyed before hatching and is part of the unsuccessful nests.

[b] Successful nest = fledged at least 1 young.

TABLE 5. Monthly census of rock doves in Stevens Point, WI.

Time	N
May 1976	850
June 1976	910
July 1976	900
August 1976	910
September 1976	950
October 1976	1000
November 1976	1010
December 1976	1020
January 1977	950
February 1977	950
March 1977	880
April 1977	1030
May 1977	890
June 1977	960
July 1977	975

1976, and no one responded to newspaper articles requesting sightings of marked rock doves outside Stevens Point. However, in 1986, a student reported shooting a banded rock dove in late 1977 at his rural farm about 10 km from Stevens Point.

We found 4 rock doves killed by hawks, 1 by an owl, 10 by car collision, and 4 by shooting. We found 4 adult and 88 juvenile rock doves dead in the 2 church nest sites, August 1976-August 1977, with a high of 14 dead juveniles in September 1976 and March 1977. Of 53 juveniles patagium-marked at the 2 churches from May through August 1977, 43% were recaptured there at the end of August 1977. Others were observed on ledges outside the churches, on nearby houses, and at communal nest sites downtown.

Tests for zoonoses produced positive results only for *Chlamydia,* which occurred in 21% of 103 blood samples examined for it. Of 224 blood smears examined for parasites, 3% contained 7 *Haemoproteus* and 1 suspected *Plasmodium.* These results reflect a low incidence of parasites compared to other studies (Table 6). No other zoonoses were found in the 451 blood samples, 384 cloacal swabs, and 15 fecal samples examined.

Movement to Food and Water.—The Soo Line railroad track area within Stevens Point's city limits was the main feeding area. Most rock doves spent at least part of each day there. After snow melt this source was augmented by seeds and litter picked up in an athletic field and throughout the city, but the tracks were the main food source. Water was obtained from pools on buildings after precipitation and from the Wisconsin River. The Wisconsin River was used more often during summer.

Observations revealed the following daily schedule for rock doves in Stevens Point during summer:

Sunrise to 1 hour after—about ⅓ of the city's rock doves were feeding, courting, and flying in the Soo Line track area. Others were occupied with young and/or eggs or loafed near the roost area.

Rest of morning—the rock doves were back around the roost site or in its general area. They loafed in the sun or picked up food and grit nearby. Noon through afternoon—the birds were back at the Soo Line tracks, but not all at the same time. During this period, small groups (4-25) were constantly leaving and flying into the area; only 150-300 birds could ever be counted at any one time at the railroad tracks. However, during this period most of the city's rock dove population visited the Soo Line track area as the primary food source in the city, as evidenced by color-coded patagial tags and spray-painted wings.

One hour before sunset to sunset—the rock doves were in or near the roosting area, loafing or feeding.

Sunset—all rock doves were roosting.

During winter the schedule changed in that the rock doves arrived at the tracks 3 hours after sunrise and left 3 hours before sunset. They spent proportionally more of

TABLE 6. A comparison of various geographical locations for the incidence of *Haemoproteus columbae* in rock doves.

% infection	N *rock doves Sampled*	*Location*	*Authority*
3.0	224	Stevens Point, WI	This study
58.3	60	Henrico Co., VA	Jochen 1962
82.2	—	Honolulu, HA	Kartman 1949
57.7	—	Parana, Brazil	Giovanni 1946

their time in the track area during winter because it was their only food source and no nesting occurred. Therefore, we saw larger concentrations (500-800) at the tracks during winter. Spring and fall were transitional periods between the 2 schedules.

Discussion

Nesting and Roosting Sites.—Rock dove roosting/nesting sites in Stevens Point were characteristic of those in other urban areas (Potts and Wolmendorf 1960, Scott 1961, Woldow 1972). Feral rock doves are colonial nesters like their ancestors which nest in coastal caves (Gompertz 1957) and roost in groups (Goodwin 1960). Rock doves in Stevens Point used only 12-15% of available house roosts and all available communal sites. Communal sites were crowded. House sites may be marginal habitat for rock doves, perhaps occupied by surplus or subordinate birds from overcrowded communal sites, as Murton et al. (1974) suggested.

We observed no seasonal preference of nesting sites. Rock doves leave sites exposed to cold weather winds (Woldow 1972), and move to locations not facing prevailing winds (Murton et al. 1972*b*). The rock doves of Stevens Point were observed to avoid cold winter winds, seek shade during hot summer days, seek sunlight during cold winter days, and avoid the north and west sides of houses which receive the harsh cold winds of Wisconsin's winters, and the south side which was hot during nesting in summer. Overhanging eaves of dormers and the proximity of other houses apparently provided enough protection from the weather all year on some houses. Rock doves used certain houses as loafing areas during winter days; these houses had poorly insulated, gently sloping roofs. Roofs too steep were difficult to walk on. Poorly insulated roofs radiated heat which reduced snow and perhaps warmed the rock doves.

Population Characteristics.—The relative monthly stability of the rock dove population probably was due to a combination of year-round availability of food and water, relatively few breeders (49%), distributing reproduction over a long time (9 mo.), and probably high dispersal rates. The size of the rock dove population (850-1030) in Stevens Point may be related to the number of communal nest sites within the city, food availability, and low incidence of parasites and disease. Four large sites not intensively studied in the downtown area were used by 300 rock doves, but only an estimated 18% nested in what may have been generally unsuitable nesting habitat with few nest sites. These sites also may have contained many young-of-the-year from other sites; young rock doves marked from the 2 churches were seen at these sites.

Human-related activities probably were the major mortality factors for adult rock doves. Most of the increment of young birds could not be accounted for later, and may have dispersed outside the city or the population pressure may have forced subordinate non-breeding adults to disperse. Because many fledged young-of-the-year were forced from their natural area by established adults, they probably sustained higher mortality than adults from shooting and trapping. Fledging success in Stevens Point compared favorably with that in Maryland (Schein 1954), England (Murton et al. 1972*a*), and New Zealand (Dilks 1975) even though weather extremes are greatest in Stevens Point. Mortality of squabs may result from exposure, disease, and sibling rivalry. Murton and Clarke (1968) stated that the weakened condition of adults in late summer due to moulting, rearing several clutches, and a lack of food supplies caused higher nestling deaths. The cold winters of Stevens Point may eliminate rock doves that are weak or subordinate. Weak birds which are often chronic or subclinical disease carriers may succumb with the added stress of weather. Subordinate rock doves also may be culled from the population by exposure to winter weather.

The 2 church communal nest sites pro-

duced more young than the house sites partly because rock doves prefer communal nest sites; more rock doves are available to produce more young there. The apparent difference in the number of birds fledged probably is due to most birds in the churches nesting and many renesting. House nesting birds laid only 1 clutch or did not nest during a 5-month period. Murton et al. (1974) stated that rock doves which could not establish themselves at their natal area were subordinate. Murton et al. (1974) also stated that reproduction was best at the natal area. Displaced rock doves from the Stevens Point communal roosts therefore might not be as successful.

Ready sources of food and water in Stevens Point were available throughout the year only a short distance from the nest sites. Especially important is the availability of food and water at the railroad tracks during winter, when the ground is covered with snow. The food that is eaten at the tracks is supplemented by weed seeds found within the city during spring and summer. Murton et al. (1972*a*) stated that food directly affected the breeding success and size of a population of rock doves in Manchester, England. Ricklefs (1972) stated that the number of clutches is an integral part of the annual fecundity and depends in large part on the length of the season that is suitable for reproduction. Ricklefs (1972) also noted that the long breeding season in rock doves is attributed to their varied and flexible diet.

The results of the rock dove nuisance survey and the complaints which led the city of Stevens Point to invite and support our study suggest that rock doves are a valued wildlife resource, but that the density of 76 rock doves/km^2 is too high. Public opinion must be considered in management objectives. Efforts should be aimed at maintaining an acceptable population size by monitoring and managing on an annual basis. Temporary rock dove control, such as shooting, trapping, drugging, poisoning, repellents, or destruction of nests and eggs, have been tried in other cities with relatively little success (Scott 1961) because they are short term in effect. The public often is offended by many of the temporary control measures (Penn 1965). Some of these are of value when used in conjunction with more permanent measures.

Control efforts should concentrate on nest site elimination and prevention. These methods offer permanent control and have been part of successful rock dove control programs (Potts and Wolmendorf 1960, Scott 1961). In the case of Stevens Point, the dependable source of food at the railroad station was probably the key factor, especially in winter, in maintaining the population of rock doves at 76-89/km^2. The daily practice of washing out grain cars with hot water provided a regular source of food, grit, and water during these critical months. Reduction of the rock dove population probably would occur if the station could reduce the spillage of grain atop grain cars and on the tracks, and if it could wash the cars less often, inside a building, or on top of a single catch basin to which the birds were prevented access.

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Literature Cited

Dilks, P. J. 1975. The breeding of the feral pigeon in Hawke's Bay, New Zealand. Notornis 22:295-301.

Gompertz, T. 1957. Some observations on the feral pigeon in London. Bird Study 4:2-13.

Goodwin, D. 1960. Comparative ecology of pigeons in inner London. British Birds 53:201-212.

Giovanni, M. 1946. Fauna parasitologica parenese. I. *Haemoproteus columbae,* Celli and Sanfelici, 1891 em *Columba livia* nos Pombias de Curitiba. Arg. Biol. e. Tecnol. 1:19-21.

Jochen, R. F. 1962. A survey of parasites in a population of pigeons (*Columba livia,* Gmelin) in Henrico County, Virginia. M.S. thesis, Univ. Richmond, Richmond, VA. 63 pp.

Kartman, L. 1949. Observations on the *Haemoproteus* of pigeons in Honolulu, Hawaii. Pacific Sci. 3:127-132.

Murton, R. K., and S. P. Clarke. 1968. Breeding biology of rock doves. British Birds 61: 429-448.

_____, C. F. B. Coombs, and R. J. P. Thearle. 1972*a*. Ecological studies of the feral pigeon *(Columba livia)* Var. I: population, breeding biology and methods of control. J. Appl. Ecol. 9:835-874.

_____. 1972*b*. Ecological studies of the feral pigeon *(Columba livia)* Var. II: flock behaviour and social organization. J. Appl. Ecol. 9:875-889.

_____. 1974. Ecological studies of the feral pigeon *(Columba livia)* Var. III: reproduction and plumage polymorphism. J. Appl. Ecol. 11:841-854.

Penn, L. A. 1965. Pigeon control in Milwaukee. Pest Control 33:16-18.

Potts, R. M. and D. J. Wolmendorf. 1960. Pigeon control in Fresno, California. Vector Views 7:59-62.

Ricklefs, R. E. 1972. Fecundity, mortality and avian demography. Page 366-434 *in* D. S. Farner, ed. Breeding biology of birds. Nat. Acad. Sci., Washington, D.C.

Schein, M. W. 1954. Survival records of young feral pigeons. Auk 71:318-320.

Scott, H. G. 1961. Pigeons—public health importance and control. Pest Control 29:9-20.

_____. 1964. Pigeon-borne disease control through sanitation and pigeon stoppage. Pest Control 32:14-15.

Solman, V. E. 1974. Aircraft and wildlife. Pages 137-141 *in* Symposium on wildlife in an urbanizing environment. Coop. Ext. Serv., Univ. Massachusetts, Amherst.

Woldow, N. L. 1972. Studies on the reproductive capacities of birds with a field study of the feral rock dove, *Columba livia,* L., in the urban environment. Ph.D. thesis, Rice Univ., Houston, TX. 169 pp.

IDENTIFICATION OF WISCONSIN CATFISHES (ICTALURIDAE): A KEY BASED ON PECTORAL FIN SPINES

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Abstract

A key to the pectoral fin spines of the freshwater catfish of Wisconsin is provided and these are compared with the spine characters as described from regions adjacent to or near Wisconsin. The key is based upon the size, shape, and orientation of the spines and the bony structures found on them.

INTRODUCTION

Identification of catfish species is not always easy. Conventional means of identification are such features as the number of anal fin rays and the color of chin barbels, which are not always conclusive since there is considerable overlap between species. For example:

Overlap of anal ray counts in the genus *Ictalurus* (Slastenenko 1958, Pflieger 1975, Becker 1983).

species	anal ray count		
	Slastenenko	Pflieger	Becker
Ictalurus melas	16-22	17-21	15-21
Ictalurus nebulosus	19-24	22-23	21-24
Ictalurus natalis	23-28	24-27	24-27

The present study confirms that, by analyzing pectoral fin spines alone, most Wisconsin catfishes can be identified to species.

Since pectoral fin spines are persistent bony structures they are useful in providing the biologist with an important tool for the identification of badly decomposed specimens, skeletal materials, and food habits of fish-eating birds, mammals, and reptiles.

MATERIALS AND METHODS

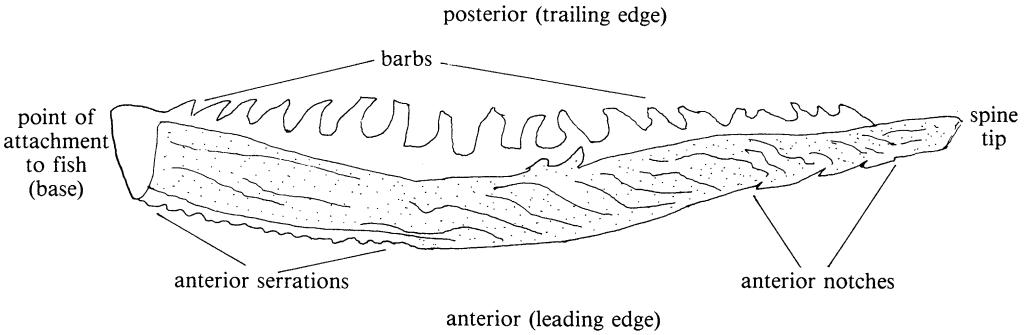
The following key to the spines of the ictalurids of Wisconsin is based upon the observation of spines from 571 *Ictalurus melas,* 102 *Ictalurus natalis,* 83 *Ictalurus nebulosus,* 60 *Ictalurus punctatus,* 4 *Pylodictis olivaris,* 145 *Noturus gyrinus,* 74 *Noturus flavus,* and 44 *Noturus exilis.* Personal collections were made from the Oconomowoc River and from the Wisconsin River, but the principal source of specimens was the Museum of Natural History at the University of Wisconsin in Stevens Point.

In this study the right pectoral spine, while held at right angles to the body was removed flush with the body using a jeweler's saw. The portion of the spine removed included the main shaft and its toothlike projections (barbs). Fin tissue was thoroughly teased from the spine with pins, razor, and forceps using a 20X dissecting scope. Characteristics of the ventral side of the spine were noted. Occasionally bony material on the dorsal side obscures size and shape of some barbs.

The bottom (ventral) side of the spine often shows important distinguishable features more readily than the top (dorsal) side. This is particularly true near the base of bullhead spines where bone on the dorsal side often obscures detail. Hence all drawings of the right pectoral spine which follow are made from the bottom (or ventral) side.

If one were to lay a fish upon its back with the tail pointing away, the spine on the right would be in the same position as the drawings in the key. Drawings of spines indicate typical shape and average adult size.

Terms used appear as follows:



Results

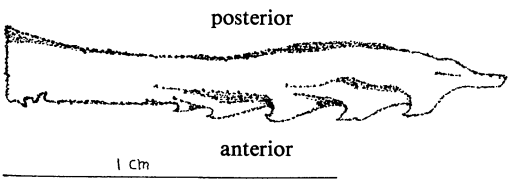
Key to Spines of the Ictaluridae of Wisconsin

1a. Barbs not present on posterior edge . 2

1b. Barbs present on posterior edge 3

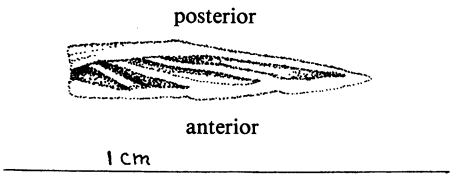
2a. Anterior notches prominent, wide, and deep, extending from tip at least halfway along shaft of spine. Surfaces of the base half of spine smooth and unfurrowed.

STONE CAT
Noturus flavus Rafinesque



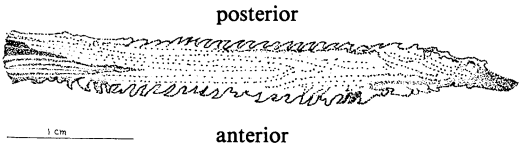
2b. Anterior notches, if present, are delicate and short, and limited to near tip. Both dorsal and ventral surfaces of spine deeply furrowed.

TADPOLE MADTOM
Noturus gyrinus (Mitchell)



3a. Barbs present on both posterior and anterior edges.

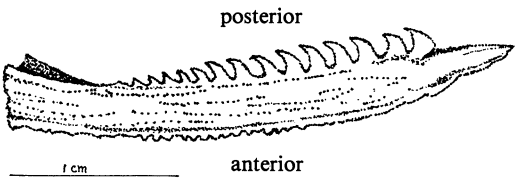
FLATHEAD CATFISH
Pylodictis olivaris (Rafinesque)



3b. Barbs present on posterior edge only 4

4a. Barb heights steadily decreasing from tip of spine to base, showing consistent strong inclination toward base.

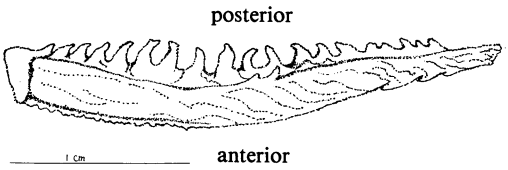
CHANNEL CATFISH
Ictalurus punctatus (Rafinesque)



4b. Barb heights not steadily decreasing from tip of spine to base some upright or showing inclination away from the base 5

5a. Barb heights on posterior edge of spine equal to or greater than one-half the diameter of spine shaft at point of barb attachment.

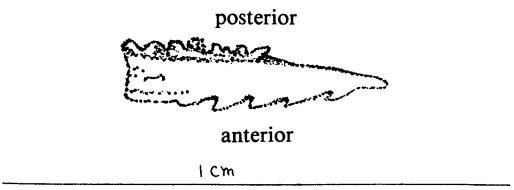
BROWN BULLHEAD
Ictalurus nebulosus (Lesueur)



5b. Barb heights on posterior edge of spine noticeably shorter than one-half the diameter of spine shaft at point of barb attachment 6

6a. Anterior notches extending from tip at least halfway along shaft of spine.

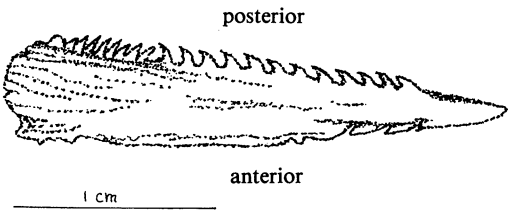
SLENDER MADTOM
Noturus exilis Nelson



6b. Anterior notches, when present, limited to tip of spine 7

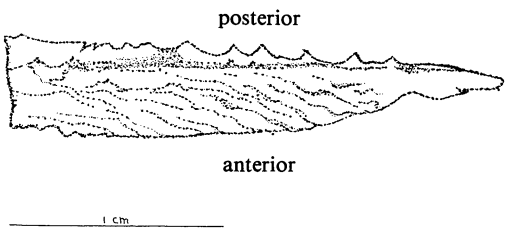
7a. Barbs from tip to mid-spine similar in size, shape, and spacing. Barbs not pyramidal in shape (as an isosceles triangle).

YELLOW BULLHEAD
Ictalurus natalis (Lesueur)



7b. Barbs from tip to mid-spine not similar in size, shape, and spacing. Barbs often pyramidal in shape (as an isosceles triangle).

BLACK BULLHEAD
Ictalurus melas (Rafinesque)



Discussion

Black Bullhead

The pectoral spines of the black bullhead are the most variable of Wisconsin catfish species, showing few consistent characteristics (see ill. under 7b of key). For this species spines with weak barbs have been reported from Illinois (Paloumpis 1963), Missouri (Pflieger 1975), Canada (Scott and Crossman 1973), Ohio (Trautman 1957), and Wisconsin (Becker 1983). Illustrations of black bullhead spines from Missouri, Canada and Ohio are smooth edged, lacking barbs.

According to Trautman, the spines of many young and some small adults may be "somewhat serrated." In Illinois, Forbes and Richardson (1920) reported that weak teeth occur only in adults, and Paloumpis (1963) has observed barbed spines at all ages.

All the Wisconsin black bullheads I examined had barbs on the spines; however Becker (pers. comm.) reported that some in-

dividuals "may have only the faintest resemblance to barbs." Although the barbs in the drawing by Becker (1983, p. 145) are less well defined than those I observed, their small size and irregularity allow correct identification to species using the above key.

Other characteristics of bullhead spines that may be useful are the anterior serrations and the anterior notch(es). The anterior edge of the black bullhead spine is generally smooth; however anterior serrations, when present, are small and limited to the part of the spine closest to the base (see ill. under 7b in the key). The anterior notch(es) near the tip of the spine appear(s) in Wisconsin black bullheads although not well defined. This characteristic has also been reported by Paloumpis (1963) from Illinois.

Brown Bullhead

The barbs near the tip of the pectoral spine of the brown bullhead point toward the base, those in the middle are erect, and the barbs near the base point toward the tip (see ill. under 5a of key). Spines from Illinois brown bullheads (Paloumpis 1963) are similarly described.

Brown bullhead spines as illustrated from Missouri (Pflieger 1975), Ohio (Trautman 1957), and Wisconsin (Becker 1983) show shorter barbs than those I observed in my Wisconsin specimens. In Ohio (Trautman 1957) and Canada (Scott and Crossman 1973) brown bullhead spines exhibit several short barbs near the base of the spine.

Yellow Bullhead

The barbs on the spines of the yellow bullhead in Wisconsin tend to be smaller, sharper, and more numerous than those of the two preceding species (see ill. under 7a in key). In Wisconsin specimens a few near the base point toward the tip.

Pectoral spines of yellow bullheads from Illinois (Paloumpis 1963), Canada (Scott and Crossman 1973), and Ohio (Trautman 1957) are similar to those on Wisconsin fish. It is noted however, that in individuals from Canada and Ohio, the barbs at the base of the pectoral spine were shown inclining toward the base instead of toward the tip. Apparently there is plasticity in the morphology of yellow bullhead pectoral spines as observed from different parts of its range. Despite this, such fish would key out correctly with the instrument provided above.

Anterior notches and serrations in the spine of the yellow bullhead are common as they are in Illinois (Paloumpis 1963) but their taxonomic use still needs determination.

Channel Catfish

Barbs on the pectoral spine of Wisconsin channel catfish incline toward the base with barb heights decreasing from tip to base (see ill. under 4a in key). This characteristic was diagrammed in the key by Paloumpis (1963).

In Canada (Scott and Crossman 1973) barbs were found to point in different directions on different parts of the spine.

Flathead Catfish

Barbs on the pectoral spine of Wisconsin flathead catfish are found along the anterior edge of the spine (anterior barbs pointing toward the base of the spine) and along its posterior edge (posterior barbs pointing toward the tip (see ill. under 3a of the key).

The barbs on the spine of a 24-year-old specimen I examined were much reduced, appearing as rounded nubs. Barbs on both anterior and posterior edges may be imbedded in the soft tissue of the fin beyond the bony spine.

Stonecat

The characteristic pectoral spine of the Wisconsin stonecat is illustrated under 2a in the key. The anterior notches are sharp-pointed and inclined toward the base. They are—as Taylor (1969) describes—"recurved hooks." In Wisconsin the posterior edge of the pectoral spine is smooth but Taylor finds

it "roughened or sometimes with a few serrae behind."

Illustrations of pectoral spines of stonecats from Canada (Scott and Crossman 1973) and Michigan (Taylor 1969) are similar to Wisconsin specimens and can readily be identified to species with the above key.

Tadpole Madtom

The pectoral spine of the tadpole madtom is short, deeply furrowed on both dorsal and ventral surfaces, lacks barbs, and the anterior notches, if present, are delicate and short (see ill. under 2b in key). Descriptions of tadpole madtom spines from Ohio (Trautman 1957) and Canada (Scott and Crossman 1973) agree with my observations. Illustrations by Pflieger (1975) and Taylor (1969) of pectoral spines from Missouri specimens agree with my observtions and can easily be identified to species with the above key.

Slender Madtom

The barbs on the pectoral spine of the slender madtom in Wisconsin are generally columnar, blunt-tipped, and occasionally with flat tops having small projections (see ill. under 6a in key). The barbs are generally perpendicular to the shaft of the spine, although some inclination of barbs is not unusual. Often barbs close to the tip lean toward the tip. Taylor (1969) also found barbs "usually straight, but sometimes bent outward or inward."

The distinct anterior notches or "retrorse hooks" (Taylor 1969) extend from the tip at least halfway toward the base of the spine.

ACKNOWLEDGMENTS

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LITERATURE CITED

Becker, G. C. 1983. Fishes of Wisconsin. Univ. of Wis. Press. 1052 pp.

Forbes, S. A. and R. E. Richardson. 1920. The Fishes of Illinois. Ill. Nat. Hist. Surv. Bull. 3. 1-351.

Paloumpis, A. A. 1963. A key to the Illinois species of Ictalurus (Class Pisces) based on pectoral spines. Trans. of the Illinois Acad. Sci. Vol. 56(3):129-133.

Pflieger, W. L. 1975. The Fishes of Missouri. Missouri Dept. of Conservation. 343 pp.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Canada, Ottawa. Bull. 184. 966 pp.

Slastenenko, E. P. 1958. The freshwater fishes of Canada. Kiev Printers, Toronto. 383 pp.

Taylor, W. R. 1969. A revision of the catfish genus *Noturus* Rafinesque with an analysis of higher groups in the Ictaluridae. Smithsonian Inst., U.S. Natl. Mus. Bull. 282. 315 pp.

Trautman, M. B. 1957. The fishes of Ohio. Ohio State Univ. Press, Columbus, Ohio. 683 pp.

SOME MODERN IDEAS IN ANCIENT INDIA

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Although the East is often referred to as an ancient civilization and India recognized as having had a great past, little is generally known about India's contribution to the world. Some Western writers occasionally turn lyrical when they speak of India's heritage and pour encomium about her past,[1] but there is often a noticeable reluctance among most Western writers to put India before other countries in certain matters where she has clearly excelled. It is not uncommon for a Western Indologist to be excited on first discovering India's greatness in some area and then cool off on second thought. An excellent example is Max Müller, who at first was excited but then became critical.[2] Ancient Indian achievements were both great and varied, and while it is impossible to go into a full discussion of them in this essay, an attempt is made here to recount and explain some of the modern ideas which existed in ancient India.[3]

First and foremost, perhaps, it should be noted that the word *Ārya* comes from Sanskrit, the ancient classical language of India, and etymologically means "to till," while its literal meaning is "noble." The word abounds everywhere in India's ancient writings. According to Western scholars, the Aryans came to India and settled by about 2,000 B.C. They developed the art of agriculture and were the first in the world to grow rice.[4] They domesticated the cow and got from it milk, butter, and ghee.[5] As civilization advanced, their predatorial habits disappeared (though it has been argued that they were never meat-eaters), and they became vegetarians. They are supposed to have drunk *soma*[6] (see Aldous Huxley's *The Brave New World* for a reference to this drink) and much later developed *panchāmrita,* a drink consisting of five ingredients, used even today on festive and religious days, probably a forerunner of the modern punch.[7] The swastika sign originated in ancient India (and is still used on religious and other important days), though the symbol is reversed in the West. The word *swastika* is itself a Sanskrit word and means "the religiously good or auspicious."

One of the most fascinating things our ancestors imagined is space travel. Not only do we have in the first epic, the *Rāmāyaṇa,* an aerial car called Pushpaka that travels from city to city, from country to country, and from planet to planet but we have descriptions of inter-planetary battles. What is more strange, the plane is an automatic, pilotless one. Elsewhere there is an account of crafts used to travel on water, on land, and in air—all in one craft—with some specifications.[8] In the same epic we have flights by Hanuman and also building of bridges across bays—for example, from India to the island of Ceylon.

This epic abounds in the description of the strange and the fantastic. There are, here, weapons of war and destruction not imagined elsewhere till modern times. There are descriptions of weapons, counter-weapons, counter-counter weapons, and counter-counter-counter weapons, and so on. There is, for example, the fire weapon (Āgnyeyāstra), which the hero of one army might release so as to burn down all that is on the other side of the battle field, but before fire envelopes the whole place (compare napalm or cluster bombs), the opponent releases the water weapon (Vāruṇāstra) putting out the fire while at the same time trying to flood the other side of the battlefield. But the hero quickly releases the

Wind weapon (Vāyuvyāstra), which will disperse the water, and so on. There are even terrible world-destruction weapons and missiles like the Aindrāstra, Pāshupatāstra, Vaishṇavāstra, and finally the ultimate weapon, which can destroy the whole world, Brahmāstra. The last one is unstoppable except by the one who releases and knows how to retrieve it before it hits the target. The knowledge of these weapons is restricted to the few who have been taught by a holy preceptor and who have earned by merit their secret and use. There is even in this epic an instance of something like a chemical weapon (sammōhanāstra),which makes the victim lie helplessly foaming at his mouth. As though this were not enough, we have one instance in which the hero, Rāma, uses a straw to convert its atom into an atomic weapon to destroy a demon attacking Sitā, the heroine.

There are strange beings, animals, and birds, too, in this epic, which we come across in the volume entitled the Forest Volume (Araṇya Parva)—mis-shaped animals, animals with huge bodies but extended limbs with which to scoop up their prey for food, birds far bigger than the condor (Jathāyu), and later a demon looking like a hill (Kumbhakarna). The *Rāmāyaṇa* also tells of the Kingdom of the Apes with descriptions of very advanced skills, organization, and knowledge of sophisticated weapons, including some battles and skirmishes. There are many, many noble thoughts, but one of the thoughts that a successful politician of the present day might remember is what Rama the hero is told: *Avasthā pūjyate Rāma, sharīram na pūjyate*—it is the office one holds that is worshipped, not his person. The *Rāmāyaṇa* also affirms a fantastic belief that life sleeps in matter, breathes through plants, speaks through animals, and is completely conscious in man. The story of Ahalyā, who becomes a stone and rises from it again, is astonishing in its foreshadowing of the modern researchers' finding life in the deep sea, frozen antarctic, and hard rocks.

In the *Bhāgavatha* the concept of cities hanging in outer space appears. The story of Tripurāsura (the Three-City Demon), who owns the city is a terrible story of a demon who inflicts punishment on those whom he does not like by descending with his entire city and alighting on an earthly city! The idea that a man in outer space is simply suspended is best illustrated by the story of Trishanku, who tries to ascend to heaven bodily and is rejected at heaven's gate but is stopped again by the sage Vishwāmithra with the result that the King Trishanku simply is suspended in space! The famous Ten Incarnation stories of Vishṇu or the Dashāvatāra stories are a remarkable set of stories which affirm a variety of beliefs. These incarnations of Vishṇu, the Protector, are believed to have happened in an order which is fascinating for certain implications. Vishṇu is supposed to have come down to earth at the request of the human belings, age after age, to destroy evil and to uphold righteousness in the following order: the Great Fish; the Great Tortoise; the Great Boar; the Great Half-Man and Half-Lion; the Dwarf Man; Rāma with an Axe; Rāma, the Great Archer; Krishṇa, the Diplomat; the Compassionate Buddha; and finally Kalki, although the very orthodox do not accept the ninth one. Biological evolution is clearly and simply illustrated by these incarnations. Social evolution is illustrated by the gradual advance of weapons of war and destruction culminating in the most sophisticated ones mentioned earlier, which are then followed by diplomacy as a means of settling disputes and compassion as the ultimate salvation of mankind. The stories, moreover, affirm a cardinal principle of Hinduism that God is realized by each being at its own level and that God appears to different people in different ways in different ages and speaks in different tongues. In the story of Rāma with an Axe (Parashurāma), there is the affirmation of yet another idea—that it is the father who is the true parent and who passes on the heritage. For, when his

father, who suspects his wife of infidelity, tells the son to kill his mother, the son hesitates to carry out the behest of the father but finally resolves his dilemma and decides that it is the father who is the true parent. The story of Balarāma, the older brother of Krishṇa, illustrates yet another modern idea. When Kamsa, the demon, tries to kill all babies because of the prophecy in heaven that a certain baby will kill him and become the king (reminiscent of Herod-Jesus story), the embryo in the womb of Devaki is transferred to another woman's womb and Krishṇa's older brother is saved. Later on, of course, Krishṇa is born, taken to a cowherd's house and is brought up there, and he finally kills Kamsa. The story of embryonic transfer dating back some 3,000 and more years is astounding. The same work contains the parallel of the story of Noah's Ark—with one difference. In the Indian story it is not pairs of actual animals that are put in the ark but the seeds of pairs, something that can be more realistically accommodated in an ark.

In the second epic, the *Mahābhārata* (the longest ever to be composed by the human mind—it has about 100,000 verses of 32 syllables each, and the epic is in 18 volumes), we have even more modern ideas. For example, the story of Abhimanyu's learning the peculiar war strategy of Padmavyūha (of organizing a battle army) when it was being described by Krishṇa to his sister, Subhadra, in whose womb the unborn Abhimanyu is still resting, contains an extraordinary idea of teaching a fetus and attests to an old Indian belief that one's education begins in the womb and ends in the tomb. Again, the birth of the Pāndavās, the heroes of the epic, by means of the power of the holy spirits of gods invoked by Kunthi, (and her earlier pregnancy while yet a virgin without human intercourse) clearly foreshadows the story of Christ's birth. The way in which the 100 children are born to Gandhari (the idea of humans coming out of eggs—not believed in by the moderns till probably around the beginning of the century—and of one splitting up into 100) is certainly an astonishing idea, however rudimentary it may be. The *Mahābhārata* also contains a highly developed code of warfare and of treating enemies, including those who surrender. Descriptions of fantastic war weapons repeat themselves in this epic. There are also interesting descriptions of gambling and wrestling matches—when we are back about 3,000 years in time. Karate, it must be remembered, originated in India.[9]

Scattered in a number of places are other fascinating ideas. Constantly we come across the concept of *Divya drishti,* or literally *divine sight.* What this means is that sages and others who are advanced beings can tune their minds and know what is happening, has happened, or will happen—so long as the frequency of their mind is in tune with the thing about which they want to know.

Diamonds, cotton, rice, and peacocks came originally from India. In fact, the Golconda mines of the southern part of India were the mines from which the world received all its diamonds in ancient times.[10] In the words of Basham, "India has conferred many practical blessings on the world at large; notably rice, cotton, the sugar cane, many spices, the domestic fowl, the game of chess (p. 208), and, most important of all, the decimal system of numeral notation, the invention of an unknown Indian mathematician early in the Christian era (p. 495f)."[11] It was India and not the Arabs who invented the so-called Arabic numerals. The myth of Arabic invention has gone on too long. There is incontrovertible evidence to prove that India contributed these numerals and the concept of zero to the world. Basham pointedly mentions this fact:

> The earliest inscription recording the date by a system of nine digits and a zero, with place notation for the tens and hundreds, comes from Gujarat, and is dated A.D. 595. Soon after this however, the new system had been heard of in Syria (p. vi), and was being used as far afield as Indo-China. Evidently the system

was in use among mathematicians some centuries before it was employed in inscriptions, the scribes of which tended to be conservative in their system of recording dates; in modern Europe the cumbrous Roman system is still sometimes used for the same purpose. The name of the mathematician who devised the simplified system of writing numerals is unknown, but the earliest surviving mathematical texts—the anonymous "Bakshali Manuscript," which is a copy of the text of the 4th century A.D., and the terse *Āryabhatīya* of Āryabhata, written in A.D. 499—presuppose it.

For long it was thought that the decimal system of numerals was invented by the Arabs, but this is certainly not the case. The Arabs themselves called mathematics "the Indian (Art)" (*hindisat*), and there is now no doubt that the decimal notation, with other mathematical lore, was learnt by the Muslim world either through merchants trading with the west coast of India, or through the Arabs who conquered Sind in A.D. 712.

The debt of the Western world to India in this respect cannot be overestimated. Most of the great discoveries and inventions of which Europe is so proud would have been impossible without a developed system of mathematics, and this in turn would have been impossible if Europe had been shackled by the unwieldy system of Roman numerals. The unknown man who devised the new system was from the world's point of view, after the Buddha, the most important son of India. His achievement, though easily taken for granted, was the work of an analytical mind of the first order, and he deserves much more honour than he has so far received.[12]

There is a question in the history of mathematics asked about India: "When the whole world was groping in darkness, what did India contribute?" The answer is, "Nothing." This Nothing has been the most important thing in the development of mathematics. Again, Basham says,

> "For π Āryabhata gave the usual modern approximate value of 3.1416, expressed in the form of a fraction 62832/20000. This value of π, much more accurate than that of the Greeks, was improved to nine places of decimals by later Indian mathematicians. . . . He [Bhāskara] also established mathematically what had been recognized in Indian theology at least a millenium earlier, that infinity, however divided, remains infinite, represented by the equation $\frac{\infty}{x} = \infty$."[13]

He also adds,

> "Despite their inaccurate knowledge of physiology, which was by no means inferior to that of most ancient peoples, India evolved a developed empirical surgery. The caesarian was known, bone-setting reached a high degree of skill, and plastic surgery was developed far beyond anything known elsewhere at the time. Ancient Indian surgeons were expert at the repair of noses, ears, and lips, lost or injured in battle or by judicial mutiliation."[14]

The Oxford scholar MacDonell puts it even more accurately: "In modern times European surgery has borrowed the operation of rhinoplasty, or the surgical formation of artificial noses, from India, where Englishmen became acquainted with the art in the eighteenth century."[15] As for another aspect of medicine, MacDonell holds, "The *Atharvaveda* and the *Sátapatha Brāhmaṇa* contain an exact enumeration of the bones of the human skeleton."[16] Again, the same scholar notes, "One of the Brāhamaṇas [*sic*] observes that the sun does not really rise or set, but produces day and night on the earth by revolving."[17] A little later he adds that Aryabhata "maintained the daily rotation of the earth round its axis, explaining the daily rotation of the celestial sphere as only apparent."[18]

A number of ideas connected with language and literature arose in ancient India. The oldest grammatical text dealing especially with phonetics goes back to the times even before the famous text of Panini (4th-5th century B.C.), who by all accounts, is the most celebrated grammarian that has ever lived. His *Ashtādhyāyee* records a work which has never been equalled till recent times. Says John Lyons, "The Indian gram-

matical tradition is not only independent of the Greco-Roman but also earlier, more diverse in its manifestations and in some respects superior in its achievements."[19] He adds, "Pāṇini's grammar of Sanskrit has frequently been described from the point of view of its exhaustivness . . . its internal consistency and its economy of statement, as far superior to any grammar of any language yet written."[20] Indians were also the first to produce indexes or *Anukramaṇīs*[21] since they had to do so for the Rgveda. The first systematically arranged dictionary, the *Amarakosha,* was produced by Indians; it is unique in its arrangement of nouns, putting together all synonyms, in the form of verse stanzas, which students learn by heart as they would learn poetry. The *Panchatantra,* a seminal influence on stories of many countries of the world of ancient times, is indeed a remarkable book. Its framing device, or the frame story device, has been used subsequently by a large number of writers including Chaucer in his *Canterbury Tales.*[22] It influenced *Arabian Nights* stories, and MacDonell says, quoting another source, "The story of the migration of Indian fairy tales from East to West is more wonderful and instructive than many of those fairy tales themselves."[23]

About 4,000 years ago even as today, Indians thought of ten directions—the eight common ones plus up and down. We read about the ten directions in the Rgveda, and in the *Rāmāyaṇa,* the King is called Dasharatha, one whose chariot can go unchallenged in any of the ten directions. Similarly, in ancient times, as today, India had thought of five elements constituting the universe as well as the human body, these being fire, earth, water, air, and space. Without space, the fifth element, our bodies would simply be one single block. Again, there is a curious question asked in one of ancient scriptures with a curious answer: "What is this universe? From what does it arise? Into what does it go?" "And the answer is: In freedom it rises, in freedom it rests, and into freedom it melts away."[24] One of the weapons used by Vishṇu and Krishṇa is called Chakra (wheel). When it is released, it goes and kills the enemy and comes back—a better version of the Australian boomerang!

Indians have had their own way of computing time and their own calendar. They also thought that time was differently measured in different parts of the universe. The Indian concept of time even today as in ancient India is a circular one—not a linear concept. They had imagined then, and imagine now, that Brahman, the Creator goes to sleep for eight billion years and then wakes up again. In one of his television lectures Carl Sagan, the American scientist, has pointed out how this computation of eight billion years is very close to the scientific calculation of the contraction of the universe! One of the ancient philosophers, Patanjali, is very modern and anticipates modern science when he says, without postulating a creation, in his *Yogasāstra* that life comes into being when matter and life-force come together. The use of a rosary, washing of the feet of elders on religious occasions, putting the sacred ash on one's forehead (especially among certain sub-groups of Hindus), and praying with folded hands (a form of greeting—in contradistinction to shaking hands in the West) have all existed for more than 3,000 years in India and can be easily documented.

In the composition of secular literature also India was far advanced in ancient times. India's greatest, and not the first, dramatist, Kalidasa, who has been much extolled by English, German, and French writers lived in the 5th century A.D.—eleven centuries before Shakespeare. His dramas are complete with plots containing a king, queen, and court jester and all, and what is more, has a prologue, acts, scenes and epilogue (Shakespeare, it must be recalled, did not divide his plays into scenes). India had drama theaters built to exact specifications.[25] In secular literature ancient India was one of the

earliest civilizations to produce romances, which are only one step from what is called novels today. Dandin's *Dashkumāracharita* (6th century A.D.), Bana's *Kādambarī* (7th century A.D.), and Subandhu's *Vāsavadatta* (7th century A.D.) are great works of fiction. Horrwitz says, "Bâna has written the best Sanskrit novel."[26] Today, the word *kādambari* is used in three Indian languages (Kannada, Telugu, and Marathi) to mean "a novel." However, modern novels with all their attention to individuals and with overwrought emphasis on individuals' feelings and thoughts and the central importance of man in the world could not have been produced by ancient Indians, who regarded man as merely a speck in a vast universe except for his soul power. Only when the influence of the West, with its Judeo-Christian tradition and its belief in man as the center of the universe, reached India did India produce modern novels.[27]

One area in which ancient Indian custom and modern Western practice are virtually identical is in the area of teaching. Unlike the modern Indian practice of professors' lecturing to passive students, ancient India chose to teach on an individual basis (each student chose a teacher and the teacher would have to accept him) and by means of question-answer method. The earliest examples of this practice are to be found in the Upanishads, in which stories containing some of the highest truths of India are found to be taught in a dialogue fashion. The *Panchatantra* illustrates the use of circular thinking necessitated by the student's constant questions with the result that even before one story is finished another must begin and so on. Finally, ancient India had a passion for analysis. Indians analyzed and analyzed, and categorized and categorized. Till recently, Indian children in grade school used to learn by heart categories of various things—those that exist in two's, in three's, in four's and so on. This analysis and categorization was applied even to a passionate subject like love, of which Vātsyāyana's *Kāmasūtra* (The Hindu Art of Love) is a redoubtable example. These are some of the modern ideas of ancient India.

Notes

[1] See, for example, the respected American Scholar Arthur W. Ryder's Introduction to his translations of Kalidasa's selected writings, *Shakuntala and Other Writings* (New York: Dutton 1959). The book also carries the German poet Goethe's exaltation of Kalidasa's *Shakuntalam.* Subsequently, he modelled his *Faust* using a Prologue in the manner of Kalidasa. See also Mark Twain [Samuel Langhorne Clemens], *Following the Equator,* in *The Complete works of Mark Twain,* American Artists' ed., 24 Vols (New York: Harper, 1925) 2:16-17, for a frank and mixed reaction.

[2] When he gave his first lectures at Cambridge University, Max Müller was exultant and called the Vedas "the first words the Aryan man spoke" and later turned partly critical. Perhaps the following words from Max Müller give a flavour of is natural and spontaneous initial reaction to the discovery of India's greatness—a reaction uninhibited by other considerations. "If I were to look over the whole world to find out the country most richly endowed with all the wealth, power, and beauty that nature can bestow—in some parts a very paradise on earth—I should point to India. If I were asked under what sky the human mind has most fully developed some of its choicest gifts, has most deeply pondered on the greatest problems of life, and has found solutions of some of them which well deserve the attention even of those who have studied Plato and Kant—I should point to India. . . ." Max Müller, *India: What Can It Teach Us?* Ed. K. A. Nīlakantha Sastry 2nd ed. (Delhi, India: Munshi Ram Manohar Lal, 1961) 6.

[3] The term *ancient India* is used in this essay with the commonly accepted meaning of referring to the period from about 1,500 B.C. or 2,000 B.C. till about the 7th century A.D.

[4] See A. A. MacDonell, *India's Past: A Survey of her Literatures, Religions, Languages, and Antiquities.* Varanasi, India: Motilal Banarasidass, 1956, p. 7. Originally published by Oxford University Press.

[5] Ghee is melted butter oil, as it is called in America. In a hot country at a time when refrigeration was unknown, how astute it was of Indians some 4,000 years ago to come up with an idea to preserve butter! Even today it is the same procedure followed by all in India.

[6] Soma was a mildly intoxicating drink but sura was the forbidden one. For an interesting study of the soma plant, see R. Gordon Wasson *Soma: Divine Mushroom of Immortality* (n.p.: Harcourt, n.d.) Printed in Italy.

[7] E. Horrowitz says, "*Punch* is an Indian beverage consisting of 'five' ingredients." See *A Short History of Indian Literature* (London: T. Fisher Unwin, 1907) 140, f.n.

[8] See *The Hindu,* a very highly respected and overly cautious newspaper of India. "Aeronautics in the Vedic Age," Sunday 27 May 1973, the editorial page.

[9] Karate originated in India, but some writers merely recognize its strong influence on its development. See *The Oxford Companion to World Sports and Games,* ed. John Arlott (London: Oxford UP, 1975) 562.

[10] G. F. Herbert Smith, *Gem-Stones and Their Distinctive Characters,* (London: Methuen, 1912) 137, where he says, "The whole of the diamonds known in ancient times were obtained from the so-called Golconda mines in India."

[11] A. L. Basham, *The Wonder That Was India: A Survey of the Culture of the Indian Sub-continent Before the Coming of the Muslims,* (New York: Grove Press, 1959) 485.

[12] Basham 495-496.

[13] Basham 496. Ancient Indians had a creative mathematical imagination, and they imagined vast numbers of great magnitude. Jawaharlal Nehru gives some interesting facts about this amazing conception of stupendous numbers by Indians. Says he, "The time and number sense of the ancient Indians was extraordinary. The Greeks, Romans, Persians, and Arabs had apparently no terminology for denominations above the thousand or at most the myriad ($10^4 = 10{,}000$). In India there were eighteen specific denominations (10^{18}), and there are even longer lists. In the story of Buddha's early education he is reported to have named denominations up to 10^{50}.

At the other end of the scale there was a minute division of time of which the smallest unit was approximately one-seventh of a second, and the smallest lineal measure is given as something which approximates to 1.3×7^{-10} inches. . . . To them [Indians] the vast periods of modern geology or the astronomical distances of the stars would not have come as a surprise." *The Discovery of India* (London: Meridian Books, 1951) 97-98.

[14] Basham 499-500.

[15] MacDonell 185.

[16] MacDonell 180.

[17] MacDonell 186. See also Nehru, *The Discovery,* 76, where he says, "There is an odd and interesting passage in one of the Upanishads (the Chhandogya): 'The sun never sets nor rises. When people think to themselves the sun is setting he only changes about after reaching the end of the day, and makes night below and day to what is on the other side. Then when people think he rises in the morning, he only shifts himself about after reaching the end of the night, and makes day below and night to what is on the other side. In fact he never does set at all.'".

[18] MacDonell 190.

[19] John Lyons, *Introduction to Theoretical Lingustics* (Cambridge, England: Cambridge UP, 1971) 19.

[20] Lyons 20.

[21] MacDonell 19.

[22] See W. F. Bryan and Germaine Dempster, eds., *Sources and Analogues of Chaucer's Canterbury Tales* (New York: The Humanitties Press, 1958) 6.

[23] MacDonell 126.

[24] Nehru 74-75.

[25] A. Berriedale Keith, *The Sanskrit Drama: Its Origin, Development, Theory, and Practice* (London: Oxford UP, 1970) 358-360.

[26] Horrwitz 137.

[27] It is the theory of this author that the form of literature called novel today did not develop in India not because Indians were preoccupied with the fantastic as some have thought but because of their modesty about themselves as human beings and their correct understanding of their importance and place in the universe. They did not make man the supreme creation, God's favourite, and centre of the universe. Such a mind cannot produce a novel, where sometimes the most trivial thoughts of a character are delineated at length. Modern novels give paramount importance to the individual in a universe where the planet on which an individual lives is itself of diminutive importance.

ALLUSIONS TO THE *AENEID* IN *PARADISE LOST*, BOOKS XI AND XII

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Of all of Milton's works, the last two books of *Paradise Lost* are among those most roundly condemned. C. S. Lewis describes them as a "grave structural flaw." According to Lewis, Milton "makes his last two books into a brief outline of sacred history from the Fall to the Last Day. Such an untransmuted lump of futurity, coming in a position so momentous for the structural effect of the whole work, is inartistic. And what makes it worse is that the actual writing in this passage is curiously bad . . . Again and again, as we read his account of Abraham or of the Exodus or of the Passion, we find ourselves saying, as Johnson said of the ballad, 'the story cannot possibly be told in a manner that shall make less impression on the mind . . .' If we stick to what we know we must be content to say that Milton's talent temporarily failed him . . . Perhaps Milton was in ill health. Perhaps being old, he yielded to a natural, though disastrous, impatience to get the work finished" (129-130). This is not an isolated opinion. Kenneth Muir (143) and E. M. W. Tillyard (216, 246) both found the final books of *Paradise Lost* to be inferior artistically to the rest of the poem. And Samuel Johnson was, I suspect, responding especially to the last two books when he said that, while *Paradise Lost* is widely acknowledged to be a great work, no one, coming to the end of it, has ever wished it to be longer (108).

My secondary purpose this afternoon is to demonstrate, at least in one respect, the care with which these books were fashioned, that respect being the use of epic allusions. My primary purpose, and the one that interests me more, is to argue that, to the first readers of *Paradise Lost,* the *Aeneid* was a guide, and that in Books 11 and 12 of *Paradise Lost,* Milton uses allusions to the *Aeneid* to define the meaning and the peculiar merit of his own epic.

As any annotated edition of *Paradise Lost* makes clear, the poem is replete with allusions to epics, not only to Vergil and Homer, but also to the later Italian epics of Dante, Ariosto, and Tasso. Constant allusion to other epics is part of the genre. The *Aeneid* is filled with lines from Homer and from Ennius and Statius, Vergil's predecessors in Latin epic. Such allusions necessarily invite comparison; Vergil is reputed to have said that "it is easier to steal the club from Hercules than to take a line from Homer" (Harding, 20). The point of such a risk is to claim equality with, if not superiority to, the works alluded to. The method is apparent in the opening lines of *Paradise Lost,* where Milton claims to pursue "things unattempted yet in prose or rhyme" (1.16). Here Milton paraphrases the opening of Ariosto's *Orlando Furioso:* "At the same time I shall say of Orlando something never said before in prose or rhyme: that through love he became frenzied and insane and not that man who earlier was judged so wise." Whatever we think of the novelty Ariosto claims for his subject, the obvious disparity between the subject of *Paradise Lost* and *Orlando Furioso,* revealed by this allusion, concisely implies the superiority of Milton's epic.

For many of Milton's readers, "epic" meant the *Aeneid.* According to Davis P. Harding, Vergil's "major works—the *Eclogues,* the *Georgics,* and the *Aeneid*—form what might be called the hard core of the Renaissance grammarschool curriculum.

Of all the school authors, only Cicero was studied with a comparable intensity. It is probably not too much to say that Renaissance schoolboys practically knew Virgil by heart" (7). The first allusion to the *Aeneid* in Book XI has the same purpose as the opening allusion to *Orlando Furioso.* The subject of the comparison is the nature of deity. When Adam and Eve pray for forgiveness,

> . . . To heaven their prayers
> Flew up, nor missed the way, by envious winds
> Blown vagabond or frustrate . . . (11.14-16)

The description here echoes Apollo's response to Arruns' prayer in Book II of the *Aeneid:*

> Phoebus had heard, and in his heart he answered
> Half of that prayer; the other half he scattered
> To the swift winds. He granted this: that Arruns
> Should strike Camilla down with sudden death;
> But did not grant him safe return to his
> Illustrious homeland. This last request
> The tempests carried to the south winds.
> (11.794-98)

The contrast between the two prayers is sharp. Adam and Eve pray to God for pardon, and receive it. Arruns prays that he might slay Camilla in battle, and that he might return home safe. Apollo's response is that both Camilla and Arruns die.

Just as obvious a claim to a superior deity is Milton's use of augury in Book 11. After Eve remarks to Adam that, even though they are fallen, they might manage quite nicely in the garden of Paradise, Adam notices that the garden is changing:

> Nigh in her sight
> The bird of Jove, stooped from his airy tow'r,
> Two birds of gayest plume before him drove.
> (11.184-86)

In the *Aeneid,* the fate of swans pursued by an eagle twice influences the course of events. In Book 2, Venus uses the regrouping of a scattered flock to persuade Aeneas that his fleet, scattered by storm, has gathered safely at Carthage, and that he can find safety there also (2.393-401). In Book 12, a flock of swans attacks an eagle, forcing it to drop its prey. Juturna uses this event to persuade the Italians to break the truce and attack Aeneas (244-265). Both Venus and Juturna are divine, but their auguries are misleading and disastrous for their human audience. Juturna's counsel leads to the defeat of the Italians and the death of her brother, Turnus. Venus's counsel leads Aeneas to Carthage, where he falls in love with the queen, Dido, abandons his mission of founding Rome, is rebuked by Jupiter and so deserts Dido, who kills herself. Adam, without divine help, draws the correct conclusion, that their present situation is not secure; if the sign is misleading, it is misleading only in that it portends a worse fate for Adam and Eve than in fact occurs. Through prayer and augury, then, Milton reminds us that the classical gods, in contrast to the Christian God, are capricious, self-serving, and deceptive.

Milton does not always use the classical gods merely as obvious foils. At the beginning of Adam's vision, the archangel Michael is twice associated with Venus, and this association helps us to understand his mission. The form in which Michael appears is "solemn and sublime" (11.236):

> over his lucid Arms
> A military Vest of purple flow'd
> . . . .
> His starry Helm unbuckl'd show'd him prime
> In Manhood where Youth ended; by his side
> As in a glistering *Zodiac* hung the Sword,
> Satan's dire dread, and in his hand the Spear.
> (11. 240-41, 245-48)

Despite this militaristic and stern guise, the first allusion associates Michael with a resplendent Venus. Adam warns Eve that he sees

> From yonder blazing Cloud that veils the Hill
> One of the heav'nly Host, and by his Gait
> None of the meanest, some Great Potentate
> Or of the Thrones above, such Majesty
> Invests him coming. (11.228-33)

When Venus appears to Aeneas to urge him to Carthage, she has disguised herself as a huntress, and Aeneas recognizes her as his mother only as she leaves him:

> When she turned,
> Her neck was glittering with a rose brightness;
> Her hair annointed with ambrosia,
> Her head gave all a fragrance of the gods;
> Her gown was long and to the ground; even
> Her walk was sign enough she was a goddess.
> (1.402-409)

This allusion, for all its apparent incongruity, significantly qualifies Michael's role. Although Venus refuses to grant Aeneas the ordinary personal relationship between a son and his mother that Aeneas desires, and although Venus is in part motivated by her rivalry with Juno, she is also undeniably motivated by love for her son. Venus repeatedly intercedes with Jupiter on behalf of Aeneas and often herself gives Aeneas aid. Michael obviously is the agent of God the Father's divine justice, but the association of Michael with Venus makes us realize that Michael is, for all his military and judicial sternness, also the God the Son's agent, also the agent of divine, even parental love.

This is also the burden of the second allusion linking Michael and Venus. Having ascended the highest hill in the garden.

> Michael from Adam's eyes the film removed
> Which that false fruit that promised clearer sight
> Had bred; (11.412-14)

The allusion is to the fall of Troy. Aeneas has seen Priam slain, the Trojan forces scattered, and, frenzied, he is about to kill Helen, the cause of the Trojan War, whom he has discovered hiding at Vesta's altar. Venus appears and prevents him:

> 'And those to blame are not
> the hated face of the Laconian woman,
> the daughter of Tyndareos, or Paris:
> it is the gods' relentlessness, the gods'
> that overturns these riches, tumbles Troy
> from its high pinnacle. Look now—for I
> shall tear away each cloak that cloaks your eyes
> and clogs your human seeing, darkening
> all things with its damp fog; you must not fear
> the orders of your mother; do not doubt,
> but carry out what she commands. For here,
> where you see huge blocks ripped apart and stones
> torn free from stones and smoke that joins with dust
> in surges, Neptune shakes the walls, his giant
> trident is tearing Troy from its foundations;
> and here the first to hold the Scaean gates
> is fiercest Juno; girt with iron, she
> calls furiously to the fleet for more
> Greek troops. Now turn and look: Tritonian Pallas
> is planted there; upon the tallest towers
> she glares with her storm cloud and her grim Gorgon.
> And he who furnishes the Greeks with force
> that favors and with spirit is the Father
> himself, for he himself goads on the gods
> against the Dardan weapons. Son, be quick
> to flee, have done with fighting. I shall never
> desert your side until I set you safe
> upon your father's threshold.' So she spoke,
> then hid herself within the night's thick shadows.
> Ferocious forms appear—the fearful powers
> of gods that are the enemies of Troy. (2.601-23)

This allusion has several functions. It demonstrates once again the arbitrariness and vindictiveness of the classical gods, yet it demonstrates Venus's love for her son, and it thereby represents Michael's mission not as vindictive, but as just and loving. It is also significant (and this is the reason for so extended a quotation) for the understanding it provides us of Adam. To that vision Aeneas must submit and abandon Troy, and in doing so he takes the first step toward a new identity, toward becoming the archetypal Roman, *pater* Aeneas. That transformation demands that Aeneas dedicate himself totally to the founding of the Roman empire and to comply with the will of Jupiter. Consequently, that transformation demands that Aeneas abandon his homeland, lose his wife, deny his love for Dido and desert her, lose his father, wage a prolonged war, unwillingly, against the Italians, and die in a military

camp, never, in fact, founding a city. It demands the complete subjugation of his individuality to the state. The vision that Michael shows Adam separates him from the garden of Paradise, not by its destructiveness, but by its promise. In the course of the vision Adam comes to an understanding of *his* new identity, as father of a *fallen* race. Also, like Aeneas, through the process of the vision Adam is taught the role his descendants are to emulate. For Aeneas, it is resignation to the will of the gods and self-sacrifice for the good of the state. For Adam it is spiritual discernment and trust in God, for the sake of his descendants, but also (and this is the key difference) for his own sake.

The significance of the vision of the gods destroying Troy is underscored by a second reference to it at the end of *Paradise Lost.* This brings us to Eve, who has been sleeping through much of Books 11 and 12. Allusions to the *Aeneid* suggest that her re-appearance is delayed, in part, to emphasize her importance. Eve tells Adam:

> Wearied I fell asleep. But now lead on;
> In me is no delay; with thee to go,
> Is to stay here; without thee here to stay,
> Is to go hence unwilling. (12.614-16)

Her words are those of Anchises, the father of Aeneas, who refused to flee Troy without a sign from Jupiter. This was duly supplied:

> No sooner had the old man spoken so
> than sudden thunder crashed upon the left,
> and through the shadows ran a shooting star,
> its trail a torch of flooding light. (2.938-41)

Anchises declares:

> Now my delay is done; I follow; where
> you lead, I am. Gods of my homeland, save
> my household, save my grandson. (2.701-03)

And what follows becomes one of the most famous images of antiquity, Aeneas, fleeing the flames of Troy, bearing his aged father on his shoulders, holding his young son by the hand. This image was especially celebrated during the Roman Empire, for it expresses the devotion of youth, strength, and military prowess to the service of empire and of patriarchy. What is missing from this image is Aeneas's wife, Creusa, who does not escape Troy. She follows her husband, her son, and her father-in-law as they flee, but she becomes separated from them and is killed. Eve, of course, leaves paradise with Adam, and her association with Anchises makes Adam's and Eve's final view of Paradise an especially complex image:

> They, looking back, all th' eastern side beheld
> Of Paradise, so late their happy seat,
> Waved over by that flaming brand, the gate
> With dreadful faces thronged and fiery arms.
> (12.641-44)

This second allusion to the gods destroying Troy reminds us again of the contrast between classical and Christian gods, and reminds us that separation from Paradise, as from Troy, is a necessary step in the development of a new identity. The association of Eve with Anchises defines further that new identity, and especially distinguishes *Paradise Lost* from the *Aeneid,* for it indicates that the most important human relationship is not father and son, but husband and wife.

Milton uses the *Aeneid* to define for the reader the peculiar character of his epic. Obviously this discussion has not addressed the opinion of C. S. Lewis that the writing in Books 11 and 12 is "curiously bad," nor does it fully address the argument that the final books of *Paradise Lost* necessarily imply a decline in artistic power or reveal an unseemly haste to finish writing the poem. But it does demonstrate that, to the very end of *Paradise Lost,* Milton invokes the *Aeneid* as the standard by which to measure the argument of his own epic. And that suggests that Milton's own confidence in his artistic achievement had not diminished.

Notes

Ariosto, *Orlando Furioso.* Trans. Sir John Harrington. Ed. Rudolf Gottfried. Bloomington: Indiana University Press, 1963.

Harding, Davis P. *The Club of Hercules: Studies*

in the Classical Background of Paradise Lost. Urbana: University of Illinois Press, 1962.

Johnson, Samuel. *Lives of the English Poets.* 1925; repr. London: J. M. Dent, 1958.

Lewis, C. S. *A Preface to* Paradise Lost. 1942; repr. New York: Oxford University Press, 1961.

Milton, John. *Complete Poems and Major Prose.* Ed. Merritt Y. Hughes. Indianapolis: Odyssey Press, 1957.

Muir, Kenneth. *John Milton.* 2nd ed. London: Longmans, 1960.

Tillyard, E. M. W. *Milton.* Rev. ed. New York: Barnes & Noble, 1967.

Virgil. *The Aeneid.* Trans. Allen Mandelbaum. New York: Bantam, 1972.

PRODUCTIVITY OF RACCOONS IN SOUTHWESTERN WISCONSIN

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Abstract:

Age-specific reproduction was determined from 1,361 raccoon *(Procyon lotor)* carcasses collected in southwestern Wisconsin during the 1978-79 and 1979-80 trapping season (about 15 October-31 January). Litter size averaged 3.71 young, with 32% pregnancy for yearlings ($N=32$), and 91% pregnancy for older adults ($N=142$). Age-specific litter size remained fairly constant. About 10% of the juveniles ($N=100$) harvested in October 1979 were born mid-May and mid-July. Starvation and lack of subcutaneous fat reserves on 19 other juveniles suggested that raccoons conceived later than the normal February through March mating period may not survive a long winter in Wisconsin. Low testes weights, lack of sperm in smears, and non-extrusible penis indicated that juvenile males in southwestern Wisconsin are incapable of siring offspring. The sex ratio of juveniles (116M:100F) favored males ($P<0.05$); the sex ratio of adults did not differ (96M:100F). Of the known mortality, 98% was attributed to hunting (43%) and trapping (55%). The harvest consisted of 65% juveniles, 13% yearlings, and 22% older adults. Maximum longevity approached 10 years; few raccoons (5%) survived more than 5.5 years.

For about 30 years the Wisconsin Department of Natural Resources stocked raccoons to increase the size of the population, with no apparent success (Woehler 1957). Then, during the 1960s the raccoon population increased to the point where during the 1970s they caused damage to summer homes, agricultural crops, waterfowl nests (Woehler 1957), and young muskrat *(Ondatra zibethicus)* populations (Dorney 1954). Concurrently, interest in hunting and trapping raccoons in Wisconsin increased due to increasing pelt values. Estimated fur purchases ranged from 53,000 raccoon pelts in 1967 to an average of over 94,600 pelts during the following 10 years. Of 39 states reporting in 1976, Wisconsin ranked 4th in the harvest of raccoons (Inter. Assoc. Game and Fish Conserv. Comm. 1977, unpubl. report). Such trapping pressure led to the objective of this study, which was to determine age-specific reproduction of raccoons in southwestern Wisconsin.

C. M. Pils, L. E. Nauman, and K. D. Hall advised and reviewed the manuscript, T. Zeisler computerized the data, and trappers, hunters, and furbuyers supplied raccoon carcasses. The University of Wisconsin-Stevens Point, and the Wisconsin Trappers Association provided financial support.

STUDY AREA

Raccoon carcasses were collected within a 13-county region of southwestern Wisconsin. The region is characterized by open hills with broad ridges in southern regions to deeply incised valleys with narrow ridges in the north (Hole 1977). Croplands are found

on ridge tops and valley floors; intervening slopes are wooded.

Methods

Reproductive organs and upper mandibles of 1,361 raccoons were collected during the 1978-79 and 1979-80 fall hunting and trapping seasons (about 15 October-31 January). About 75% of the sample was collected from cooperating furbuyers once/week; the rest was saved by trappers and hunters who were instructed how to collect and store relevant organs. Most raccoons (98%) were trapped or shot, but road kills (2%) and 4 starved animals also were reported. Relevant organs were frozen for 2-3 months before analysis, and after sex, date of capture, cause of death, and county of kill were recorded.

Juvenile raccoons were distinguished from adults by the presence of canine root apical foramina (Grau et al. 1970), and aged to the nearest half month by tooth replacement patterns when possible (Montgomery 1964). All remaining specimens were aged by counting cementum annuli of an upper 1st premolar (Grau et al. 1970), because we found numerous accessory lines (Rice 1980) in upper incisors or 4th premolars.

The penis was examined from each male raccoon to determine if it could be extruded through the prepubital orifice (Sanderson 1950, 1961). Testes with attached epididymides were weighed to the nearest 0.1 g, and smears from the cauda examined for presence of spermatozoa. To reduce the bias in testes weight caused by body size differences, the average weight of each animal's testes (g) was divided by the greatest skull length (mm) and multiplied by 100 (Payne et al. 1966, Gipson et al. 1975).

Litter sizes were determined from placental scar counts from the previous breeding season (Johnson 1970). Females with turgid uteri were not examined because estrus tends to obscure the scars (Johnson 1970, Sanderson and Nalbandov 1973).

All raccoons aged at >1.5 years were designated as adults; racoons <1.5 years as juveniles; and those aged at 1.5 years old as yearlings. Barren adults refer to female raccoons that produced no offspring, either through failure to mate, failure of eggs to be fertilized, or loss of embryos before implantation or shortly thereafter, and without evidence of pregnancy or placental scars in the uterine horns.

Results

Reproduction

Males.—Average testes weights were greater ($P<0.001$) for adults than juveniles for each month of collection and all months combined. Testes of all 67 juveniles weighed ≤ 3.4 g and showed no apparent weight growth from October through January. Testes of yearlings reached the adult weight range (≥ 7.3 g) by October or earlier. Only 4% of 67 juveniles had mature sperm in the cauda epididymis; all 19 yearlings and 88% of 42 older adults were reproductively active. By December, all 14 adults and no juveniles possessed mature sperm. The baculum could be extruded through the prepubital orifice of all 37 adults, but none of 40 juveniles examined.

Females.—Of 214 adult females, 71% had been pregnant (Table 1). Of the 62 females showing no discernible evidence of placental

Table 1. Age-specific litter size[a] and percentage of barren females for raccoons from southwestern Wisconsin, 1978-80.

Age (years)	*Sample* N	*Pregnant* %	*Litter size* x
1.5	72	32.0	3.65
2.5	60	88.3	3.57
3.5	31	90.3	3.68
4.5	21	95.2	3.45
5.5	11	81.8	4.11
6.5	8	100.0	3.38
7.5	6	100.0	3.67
8.5	5	100.0	4.60
Total	214	71.1	3.71
2.5+	142	90.8	3.72

[a]From placental scar counts.

scars (considered barren), 79% were yearlings, the rest older adults. Of 72 yearlings, 68% were barren, as compared to 9% of 142 older females.

The mean litter size of 152 females was 3.71 (range 1-7). The mean litter size of yearlings (3.65) and older adults (3.72) did not differ ($P>0.05$), the mean number of young/yearling (1.17) was less ($t=9$, $P<0.01$, $N=152$) than for older adult (3.38) because pregnancy was 32% for yearlings and 91% for others. Age-specific litter size was fairly constant.

Late Litters.—Of 100 juvenile raccoons collected in October 1979, 10% were conceived later than the mating season of late January through mid-March in Wisconsin (Jackson 1961). Ages assigned to them and 7 juveniles collected in November 1979 indicated that late litters were born between 15 July and mid-September and were conceived from 15 May through mid-July (Table 2). These raccoons, and 19 additional juveniles, had no subcutaneous fat.

Sex Ratios

The overall sex ratio of 1,339 raccoons collected during this study was 109M:100F (52%). The sex ratio of 856 juvenile raccoons (116M:100F) favored males ($X^2=4.83$, $P<0.05$, 1 df); 483 adults were nearly equally divided by sex (96M:100F, $P>0.05$). Although the number of juvenile males per 100 juvenile females harvested monthly appeared higher than the number of adult males per 100 adult females, there was no significant difference ($P>0.05$).

TABLE 2. Birth and conception dates of 12 raccoon litters in southwestern Wisconsin, 1979.

Sex	Date of capture	Age[a] (months)	Date of birth	Date of conception[b]
F	10/29	1.5-2.0	Sep 1-15	Jul 1-15
M	10/29	3.0-3.5	July 15-31	May 15-31
F	10/29	2.0	Aug 20-30	Jun 20-30
M	10/30	1.5-2.0	Sep 1-15	Jun 1-15
M	Late Oct	1.5-2.0	mid Sep	mid Jul
M	11/13	3.0-3.5	Aug 1-15	Jun 1-15
M	11/13	3.0-3.5	Aug 1-15	Jun 1-15
M	11/13	3.0-3.5	Aug 1-15	Jun 1-15
F	Early Nov	3.0-3.5	Aug 1-15	Jun 1-15
M	Early Nov	3.0-3.5	Aug 1-15	Jun 1-15
M	Early Nov	3.0-3.5	Aug 1-15	Jun1-15
M	Oct-Nov	3.0-3.5	Unknown	Unknown

[a]Determined by tooth replacement (Montgomery 1964).
[b]A 63-day gestation period was assumed (Whitney and Underwood 1952).

Age Structure

Of 1,361 raccoons that were classified into age groups, 65% were collected as juveniles, 13% as yearlings, and 22% as older adults. Maximum longevity of males and females approached 8 and 10 years, respectively, although few raccoons (5%) survived more than 5.5 years.

No differences were apparent when age ratios were compared to method of capture ($P>0.05$), but 86% of 22 raccoons killed by vehicles were under 1 year old (Table 3). The juvenile:adult ratio remained relatively constant through December but indicated that there may be a greater percentage of adults harvested in January.

TABLE 3. Age composition of raccoons from southwestern Wisconsin, 1978-80.

Type of mortality	Sample N	Juveniles %
Hunted	462	64
Trapped	543	65
Vehicle kill	22	86
Unknown	334	62

Overall, 98% of known mortality resulted from hunting (43%) and trapping (55%). Road kills accounted for the remaining 2%. Equal numbers of both sexes were harvested by hunting and trapping.

DISCUSSION

Reproduction

Testes of males from southwestern Wisconsin do not reach adult size or produce sperm until at least the end of the 1st year of

life, as suggested for North Dakota (Fritzell 1978) and Manitoba (Cowan 1973). Juvenile males therefore probably contribute very little to the annual recruitment in southwestern Wisconsin. However, most juvenile males in Illinois are thought to sire most litters produced from second ovulations (Sanderson and Nalbandov 1973). Similarly, Johnson (1970) found that most males have adult-sized testes during the 1st breeding season in Alabama. The relatively short frost-free season and the long cold winters in the northern portion of the raccoon range may retard the attainment of physical maturity necessary for breeding during the 1st year of life (Fritzell 1978).

Of 72 yearling female raccoons, 32% bred, compared to 54% in Michigan (Stuewer 1943*a*), 0% in Washington (Scheffer 1950), 40% in Texas (Wood 1955), 9% in Alabama (Johnson 1970), 41% in Manitoba (Cowan 1973), 14% in North Dakota (Fritzell 1978), 36-73% in Illinois (Sanderson and Nalbandov 1973, Junge and Sanderson 1982, Fritzell et al. 1985), and 66% in Missouri (Fritzell et al. 1985). Annual variations in pregnancy rates was wider in yearlings (38-77%) than in adults (68%-96%) in Illinois and Missouri (Fritzell et al. 1985). Sanderson and Nalbandov (1973) concluded that yearling females from Illinois either conceive at the same time as adults during their 1st estrus period or do not breed until the next breeding season. Johnson (1970), Cowan (1973), and Fritzel (1978) indicated that yearlings conceive somewhat later in the year than do adults. Two groups of females, late-maturing juveniles and reovulating adults, may be reproductively active throughout most of the spring and summer (Fritzel 1978). In southwestern Wisconsin, about 10% of all juveniles harvested in October 1979 resulted from late litters conceived from mid-May through mid-July, indicating that some females are ovulating in a 3-month period during the summer.

If adverse weather conditions prevent early spring conceptions, litters from 2nd ovulations are born in the fall (Steuwer 1943*a*, Berard 1952, Whitney and Underwood 1952, Lehman 1968, Schneider et al. 1971). Sanderson and Nalbandov (1973) noted that about 16% of the juvenile raccoons purchased by furbuyers in the fall following the abnormally severe spring weather of 1960 in Illinois were born from August through October. In Manitoba, 14% of births were as late as the 1st week of September (Cowan 1973). Fritzell et al. (1985) observed 21-55% of yearlings and 22-55% of adults with 2 sets of placental scars, at least 1 of which was unsuccessful through resorption, abortion, or loss soon after birth (Sanderson and Nalbandov 1983). Females could ovulate again 1-6 months later (Whitney and Underwood 1952, Schneider et al. 1971, Sanderson and Nalbandov 1973). About 10% of the raccoons collected in October 1979 in southwestern Wisconsin were juveniles conceived from 2nd ovulations from May through July. Although deep snows during the normal raccoon mating season in February may have impeded the successful movement, location, and mating of receptive raccoons during the winter of 1978-79, the exact causes remain unknown. Malnutrition and disease in winter adversely affected the success for 1st-estrus matings in Manitoba (Cowan 1973), and both were reported in southwestern Wisconsin.

If we consider the energy demands during pregnancy, the 8-10 week nursing period, and the lengthy female-young relationship (Schneider et al. 1971, Fritzell 1977), late litters would be especially maladaptive in the severe winter climates in Wisconsin. Litters produced in the milder environments of the southern United States may be benefited by 2nd ovulation and fertile juvenile males, but survival of juveniles whelped from late breeding females would add little to the total annual recruitment in Wisconsin. Our observations of 4 starved juveniles and 19 others lacking subcutaneous fat reserves suggests that some young raccoons may not survive a

long and severe winter in Wisconsin. The body weight of juveniles in Manitoba decreased about 30% over winter, and winter mortality was possibly as high as 60% for this age class (Cowan 1973). Raccoons without placental scars weigh less than others (Sanderson and Hubert 1981, Fritzell et al. 1985). Delayed maturity and larger litters in northern latitudes apparently compensate for recruitment from late breeding yearlings in southern ranges; but age-specific litter size is relativley static, contributing little to annual changes in recruitment (Fritzell et al. 1985).

Hunting and trapping accounted for 98% of known human-related mortality of raccoons in southwestern Wisconsin. Only 2% of the raccoons reported were killed by vehicles; although an unknown number of road kills may go unreported, it appears that this is not an important mortality factor.

Age Structure

Raccoon populations in northern states have proportionately more juveniles and a more rapid turnover rate than those in southern areas (Johnson 1970). The 65% juveniles collected in southwestern Wisconsin agrees with reports of juveniles ranging from 41% to 70% of the harvest in northern areas (Stuewer 1943*a,b,* Sanderson 1951, Llewellyn 1952, Fritzell et al. 1985), and reflects differences in productivity, greater mortality from severe winters, intensive hunting and trapping pressure, and disease noted in northern areas over southern raccoon ranges (Johnson 1970). Variation in pregnancy rates strongly affects annual recruitment (Fritzell et al. 1985) because of the high number of yearlings in the breeding population.

Literature Cited

Berard, E. V. 1952. Evidence of a late birth for the raccoon. J. Mammal. 33:247-248.

Cowan, W. F. 1973. Ecology and life history of the raccoon (*Procyon lotor hirtus* Nelson and Goldman) in the northern part of its range. Ph.D. Thesis, Univ. North Dakota, Grand Forks, 161 pp.

Dorney, R. S. 1954. Ecology of marsh raccoons. J. Wildl. Manage. 18:217-225.

Fritzell, E. K. 1977. Dissolution of raccoon sibling bonds. J. Mammal. 58:427-428.

_____. 1978. Reproduction of raccoons (*Procyon lotor*) in North Dakota. Am. Midl. Nat. 100:253-256.

_____, G. F. Hubert, B. E. Meyer, and G. C. Sanderson. 1985. Age-specific reproduction in Illinois and Missouri raccoons. J. Wildl. Manage. 49:901-905.

Gipson, P. S., I. K. Gipson, and J. A. Sealander. 1975. Reproductive biology of wild *Canis* (Canidae) in Arkansas. J. Mammal. 56: 605-612.

Grau, G. A., G. C. Sanderson, and J. P. Rogers. 1970. Age determination of raccoons. J. Wildl. Manage. 34:364-372.

Hole, F. D. 1977. Photo-mosaic soil map of Wisconsin. Univ. Wisconsin Cartographic Laboratory, Madison.

Jackson, H. H. T. 1961. Mammals of Wisconsin. Univ. Wisconsin Press, Madison. 504 pp.

Johnson, A. S. 1970. Biology of the raccoon (*Procyon lotor varius* Nelson and Goldman) in Alabama. Alabama Agric. Exp. Stn., Bull. 402, Auburn Univ., Auburn. 148 pp.

Junge, R. E., and G. C. Sanderson. 1982. Age related reproductive success of female raccoons. J. Wildl. Manage. 46:527-529.

Lehman, L. E. 1968. September birth of raccoons in Indiana. J. Mammal. 49:126-127.

Llewellyn, L. M. 1952. Geographic variation in raccoon litter size. Presented at 8th Northeast. Wildl. Conf., Jackson's Mill, WV. Mimeogr. 7 pp.

Montgomery, G. G. 1964. Tooth eruption in preweaned raccoons. J. Wildl. Manage. 28: 582-584.

Payne, R. L., E. E. Provost, and D. F. Urbston. 1966. Delineation of the period of rut and breeding season of a white-tailed deer population. Proc. Southeast Assoc. Game and Fish. Comm. 20:130-137.

Rice, L. A. 1980. Influences of irregular dental cementum layers on aging deer incisors. J. Wildl. Manage. 44:266-268.

Sanderson, G. C. 1950. Methods of measuring productivity in raccoons. J. Wildl. Manage. 14:389-402.

_____, and G. F. Hubert, Jr. 1981. Selected demographic characteristics of Illinois (U.S.A.) raccoons (*Procyon lotor*). Pages 487-513 *in* J. A. Chapman and D. Pursley, eds. Proc. Worldwide Furbearer Conf., Frostburg, MD.

_____. 1951. Breeding habits and a history of the Missouri raccoon population from 1941 to 1948. Trans. North Am. Wildl. Conf. 16: 445-461.

_____.1961. Techniques for determining age of raccoons. Illinois Nat. Hist. Surv. Biol. Notes 45. 16 pp.

_____, and A. V. Nalbandov. 1973. The reproductive cycle of the raccoon in Illinois. Illinois Nat. Hist. Surv. Bull. 31:29-85.

Scheffer, V. B. 1950. Notes on the raccoon in southwest Washington. J. Mammal. 31: 444-448.

Schneider, D. G., L. D. Mech, and J. R. Tester. 1971. Movements of female raccoons and their young as determined by radio-tracking. Anim. Behav. Monogr. 4. 43 pp.

Stuewer, F. W. 1943*a*. Reproduction of raccoons in Michigan. J. Wildl. Manage. 7:60-73.

_____. 1943*b*. Raccoons: their habits and management in Michigan. Ecol. Monogr. 13: 203-257.

Whitney, L. F., and A. B. Underwood, 1952. The raccoon. Practical Sci. Publ. Co., Orange, CT. 177 pp.

Woehler, E. E. 1957. How about raccoon stocking? Wisconsin Conserv. Bull. 22(4):12-14.

Wood, J. E. 1955. Notes on reproduction and rate of increase in raccoons in the post oak region of Texas. J. Wildl. Manage. 19:409-410.

HISTORICAL CHANGES IN WATER QUALITY AND BIOTA OF DEVILS LAKE, SAUK COUNTY, 1866-1985

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Abstract

Concerns have been expressed in recent years that the water quality of Devils Lake may be deteriorating. As a result, water quality and biological studies of the lake were initiated in 1981 to determine its status. Examination of historical and recently collected physical and chemical data show considerable variation in some parameters but no clear trends toward poorer conditions were found. However, available historical data suggest changes in biological communities have occurred which may indicate or could cause poorer water quality conditions. These changes include (1) alteration of the aquatic plant community brought about by the invasion of Eurasian milfoil *(Myriophyllum spicatum),* (2) a change in fish population composition and relative abundance, and (3) an increase in phytoplankton biomass at certain times of the year. Interrelationships between these biotic changes and their possible effects on the water quality of Devils Lake are discussed.

INTRODUCTION

As a scenic and recreational resource, Devils Lake (Devils Lake State Park, Sauk County) has always been recognized as one of Wisconsin's finest. The lake's clear water has made it extremely popular with swimmers, boaters and scuba divers. Its fish population has historically provided good fishing opportunities. The unique value of Devils Lake can be attested to by over one million annual visitors to the park. However, recent observations of the lake's condition have given rise to concern that water quality may be deteriorating.

In 1981, a Wisconsin Department of Natural Resource (DNR) Task Force was appointed to investigate the problem. The Task Force concluded, based on the historical data available, that there probably had been some decline in the quality of Devils Lake and recommended that a basic data collection program be initiated to monitor conditions in the lake (WDNR Task Force Report, June 1981). A data collection program carried out jointly by park personnel, DNR Southern District staff, the Bureau of Parks and Recreation, and Research got underway in 1981 and continued through 1985.

This report is a compilation and analysis of the historical and recent data sets on Devils Lake. The data presented were derived from many different sources other than our own work, and we have tried to give other investigators due credit. Using information from so many sources unavoidably introduces data bias to varying degrees due to differences in methodologies. However, we cannot review all methods used by different investigators here and have chosen only to discuss methodologies where we felt differences were of significance. Details on methods used can be found in cited documents.

We have attempted to interpret this data,

TABLE 1. Morphometric data for Devils Lake, January, 1984.

Lake Area	*369 Acres*
Area < 3 ft.	3%
Area > 20 ft.	77%
Shoreline length	3.55 mi
Maximum depth	47 ft
Mean depth	30.4 ft
Volume	11,210 acre-ft
Watershed Area	2.65 mi^2
Elevation (Long-term mean)	962.6 ft (House, 1985)

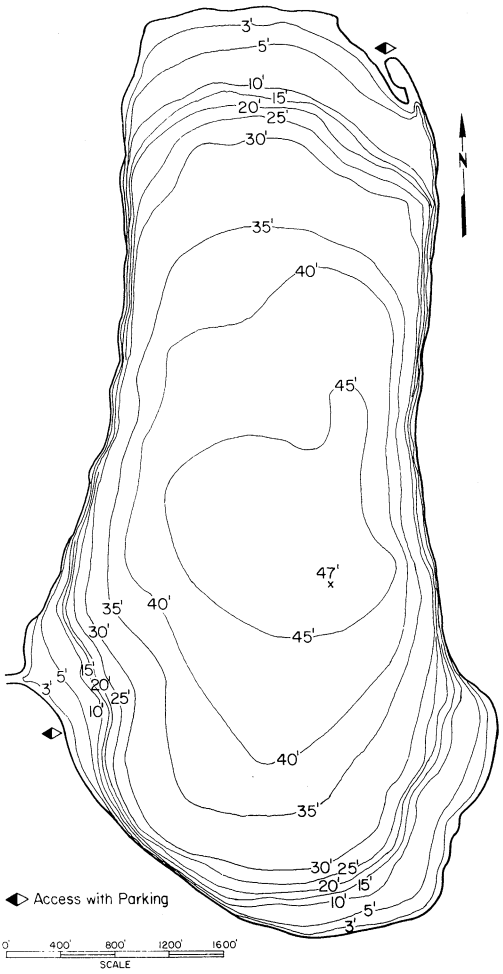

Fig. 1. Morphometric map of Devils Lake. Measurements made in January 1985, by G. Wegner and G. Quinn. Drafted by E. Eaton.

where possible, in light of the alleged changes in the lake's water quality. As is generally the case with historical water quality data sets, gaps in data collections made interpretations difficult and in most cases, prevented identification of long-term trends. We hope the information presented in this article will serve as a guide for future studies of the lake and in efforts to prevent its deterioration.

The Lake and Its Watershed

Devils Lake has a unique geologic history and origin, the story of which fills many volumes (Martin, 1916). It lies in a basin with steep rocky bluffs along the east, west, and south shorelines. Because the lake has no outlet, variations in annual precipitation are reflected in rather dramatic water fluctuations. A range in lake levels of nearly 11 feet has been recorded over a 56 year period with an average annual water-level fluctuation of 2.64 feet (House, 1985). Minimum and maximum stage were recorded in 1965 and 1973, respectively (House, 1985). Thus, morphometric data (Table 1) are dependent upon lake stage. Devils Lake is a 369 acre seepage lake with an average maximum depth of 47 feet (Figure 1).

Nearly all of the Devils Lake watershed is now in State of Wisconsin ownership, although a few small privately owned parcels still remain. The Devils Lake watershed is characterized by small size, steep relief, large areas of impervious rock surface or shallow soils and hardwood forest cover type (Plate 1, Figure 2). Because of these characteristics, surface runoff from the watershed to the lake is very rapid during storm events and snowmelt. The only permanent tributary enters the lake in the southwestern corner, and even this stream has very little flow under dry conditions. Other drainage paths are normally dry but can carry large volumes of water during major runoff events. The total watershed land area was 4.34 miles,^{2} however, only 2.65 miles^2 now drains into Devils Lake. Since the mid-1970's, runoff

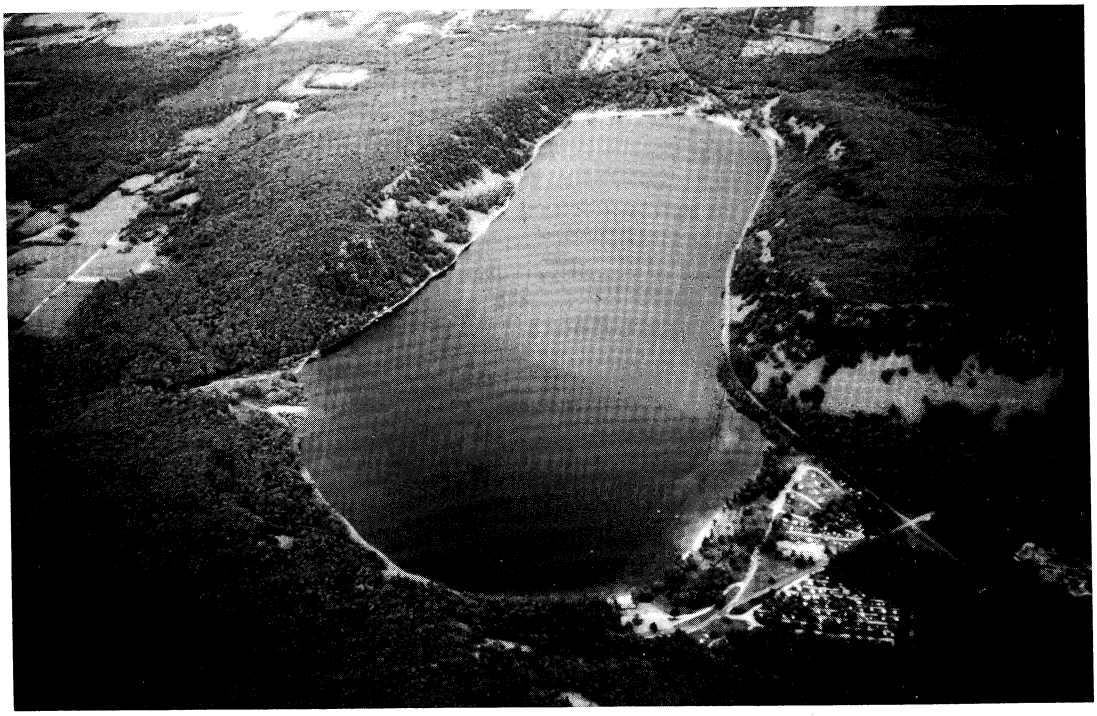

Plate 1. Air photo of Devils Lake from south.

from the northeastern subbasin has been permanently diverted to the Baraboo River.

We estimated nutrient runoff from the two main subbasins of the watershed, the southwest and the northeast, from 1970-74. Nitrogen and phosphorus concentrations in runoff were found to be similar in both subbasins (Table 2). Estimates of nutrient yields from these two watersheds (Table 3) suggested runoff coefficients were typical for forested watersheds in the U.S. (EPA, 1980). Total watershed P loading to Devils Lake (excluding atmospheric and groundwater contributions) was calculated to be 0.206 g/m²/yr. during the 1970-74 period. This was slightly above the "permissible" rate as described in various lake loading models (Dillon, 1975; Vollenweider, 1975; Uttormark and Hutchins, 1980). However, permanent diversion of the northeast subbasin drainage from the lake has reduced the annual watershed nutrient loading to the lake by about 40 percent. Nutrient loading rates now appear to be well within the "permissible" range.

Results

Historical Record—Physical and Chemical

Devils Lake is dimictic with thermal stratification beginning in late spring or

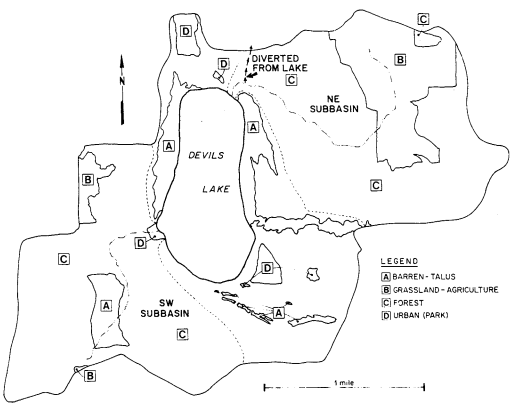

Fig. 2. Watershed map of Devils Lake. Drafted by S. Mace.

TABLE 2. Nitrogen and phosphorus concentrations in drainage waters to Devils Lake, 1970-1974. Sample nos. in parentheses.

	Southwest Subbasin		*Northeast Subbasin**	
	Range	*Mean*	*Range*	*Mean*
Organic N-mg/L	.03-1.36(29)	.29(29)	.09-.69(12)	.45(12)
Inorganic N-mg/L	.09-1.25(29)	.42(29)	.00-.91(12)	.26(12)
Total N-mg/L	.15-2.57(29)	.71(29)	.12-1.26 (12)	.71(12)
React. P—ug/L	5-137(29)	30(29)	5-111(12)	43(12)
Total P—ug/L	1-400(29)	50(29)	1-140(12)	60(12)

* Drainage now diverted from the lake.

TABLE 3. Estimated annual nutrient loading to Devils Lake from the watershed, 1970-1974.

	Southwest Subbasin (*1.36 mi²*)	*Northeast Subbasin** (1.69 mi²)	*Total Watershed* (4.34 mi²)
Watershed Loss, lbs/A/yr.			
P	0.22	0.26	0.24
N	3.14	3.14	3.14
Lake Loading, g/m²/yr.			
P	0.058	0.087	0.206
N	0.83	1.03	2.65

* Drainage now diverted from the lake.

early summer (Figure 3) and continuing through September. The duration of the spring overturn and the timing of the establishment of a permanent thermocline varies annually dependent upon climatic patterns. The depth of the epilimnion progressively increases from 18-20 feet in early summer to 30 feet by late summer (Figure 3). Erosion of the thermocline, resulting from the passage of periodic cold fronts (Stauffer, 1974), is evident in early fall as the mixing zone rapidly deepened in late September. Complete mixing generally is established by mid-November. Hypolimnetic temperatures vary from 48-53°F and do not appear to be correlated with spring weather data.

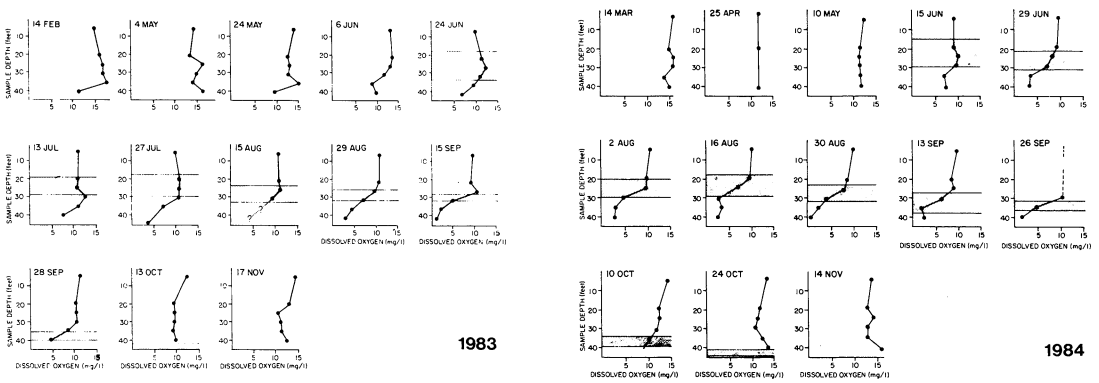

Fig. 3. Dissolved oxygen profiles for Devils Lake during a) 1983 and b) 1984 showing depth of thermocline (shaded area).

One of the most important measurements of lake water quality is water clarity or appearance. Water appearance has not been adequately measured in Devils Lake, probably because it is still clear in comparison with other southern Wisconsin lakes. However, while the written record is lacking, the collective view of many individuals is that Devils Lake is generally not as clear as it used to be. For example, scuba divers have commented upon the apparent decline in transparency in recent years.

Data to substantiate a water clarity deterioration is meager. While a considerable number of measurements of water clarity have been made over a long period of record (Figure 4), changes within seasons make comparisons difficult. Seasonal trends are evident with declining water clarity from early to late summer the rule rather than the exception. Annual trends in water clarities are less obvious although the data suggest a probable decline in water clarity during 1976-81 (Figure 5). However, clarities improved slightly in 1982 and 1985. Historically, water clarity in Devils Lake has remained very good to excellent based upon comparisons with 1140 other Wisconsin lakes (Lillie and Mason, 1983).

Dissolved oxygen (D.O.) concentration profiles within Devils Lake during the period of thermal stratification were clineograde except for occasional metalimnetic maxima (Figure 3). Epilimnetic concentrations were generally at or close to 100 percent saturation. Greatly reduced saturations occurred below the thermocline due to the decomposition and respiration processes. Over 150 D.O. profiles were collected since Birge and

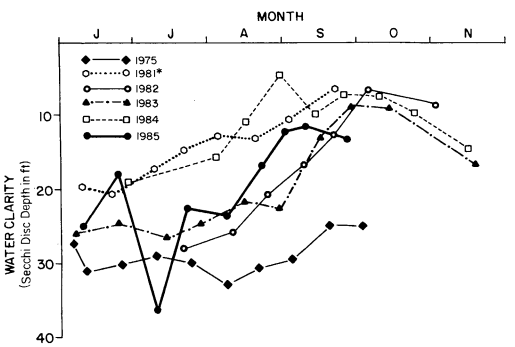

Fig. 4. Water clarity of Devils Lake for summer and fall periods of 1975; 1981-85. Data sources are listed in Figure 5.

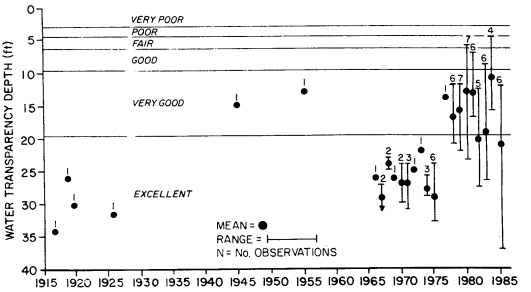

Fig. 5. Historical trends in summer water clarity of Devils Lake, Sauk County for 25 summers (July-September) from 1916 to 1985. Data sources are: Birge and Juday (1917, 19 and 26); Cline (1945); Jacob (1955); Lee (1966); WRR-DNR (1967-80); Dunst (1975); Stauffer (1971-72); Vignon and Armstrong (1974); Schlesser (1977-81); Martin (1980); and Devils Lake State Park Staff (1982-85). Water quality index based on Lillie and Mason, 1983.

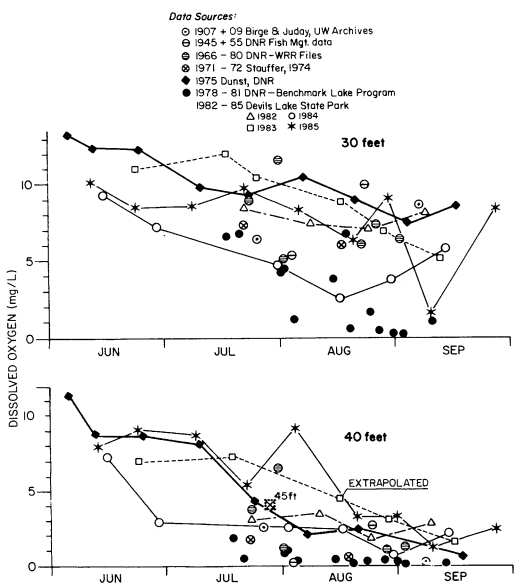

Fig. 6. Comparison of dissolved oxygen concentrations at the 30 to 40 foot contour levels of Devils Lake.

TABLE 4. Dissolved oxygen depletion rate comparisons for Devils Lake.

	Depletion Rate		
	Slope mg/L/day 30 ft.	*Slope Log mg/L/day 40 ft.*	*Summer Water Clarity*
1907*	−0.05		Unknown
1909*	−0.07	−0.016	Unknown
1972**	−0.06	−0.017	Excellent
1975	−0.05	−0.05	Excellent
1979	−0.08	−0.013	Very Good
1980	−0.12[a]	−0.022	Very Good
1981	−0.014	−0.025	Very Good
1983	−0.02	−0.005	Very Good to Excellent
1984	−0.10	−0.008	Good to Very Good
1985	−0.02	−0.006	Excellent

* Birge and Juday data in Conway, 1972.
** Stauffer data in Conway, 1972.
[a] 0.06 mg/L/day first 69 days of stratification period.

TABLE 5. Epilimnetic nutrient concentrations of Devils Lake, Sauk County, Wisconsin.

	Total Phosphorus ug/L	*Total Nitrogen mg/L*
x ± 1 SE	23 ± 1.7	0.40 ± 0.03
Range	15-51	0.16-0.56
C.V. (%)	32	28
N (Years)	19	17

Juday's first collections in 1907. No trends in dissolved oxygen concentrations were detected. Estimated hypolimnetic D.O. depletion rates, based on D.O. concentrations at the 30 and 40 foot depths (Figure 6), were significantly higher ($P<0.05$ at 30 feet, $P<0.10$ at 40 feet) in years with reduced water clarities (Table 4). D.O. depletion rates decreased in 1983, deteriorated (increased) in 1984, and improved again in 1985, exhibiting rates very similar to those measured during 1975. Thus, D.O. concen-

TABLE 6. Comparisons of epilimnetic total phosphorus concentrations (ug/L) from Devils Lake for various years. Superscript numbers refer to frequency of sampling.

Years	*July*	*August*	*September*	*October*	*Source*
1971-72	12[2]	11	—	26	Stauffer, 1974
1978-80	20[3]	20[3]	20	—	DNR-BLP; WRR
1981	13	12	11	—	DNR-BLP
1982	9	10	27	25	DNR-DLSP
1983	13[2]	17	17	25	DNR-DLSP
1984	—	22	24	29	DNR-DLSP
1985	15	16	—	—	DNR-DLSP

Data Source Codes: DNR-BLP = Benchmark Lake Program
DNR-DLSP = Devils Lake State Park
DNR-WRR = Water Resources Research Section

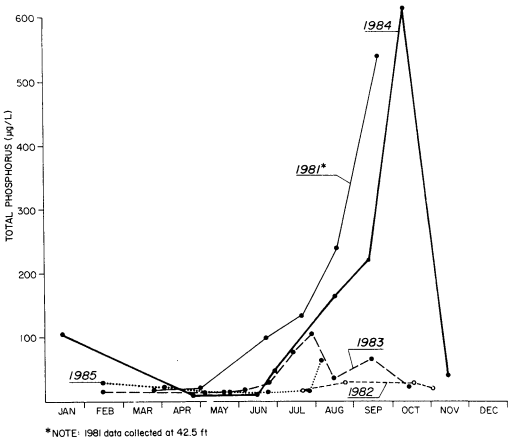

Fig. 7. Total phosphorus concentrations (ug/L) in the hypolimnion (40 foot depth) of Devils Lake, 1981-85.

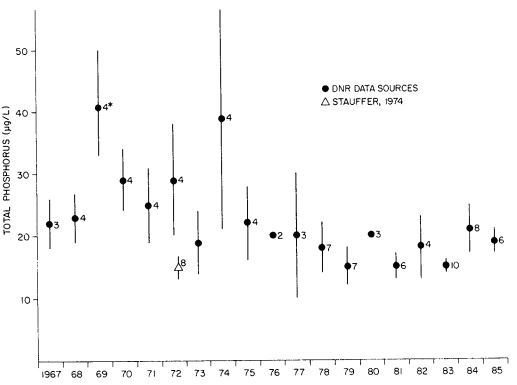

Fig. 8. Epilimnetic total phosphorus concentrations ($\bar{X} \pm$ 1SE) in Devils Lake during 1967-85. (N) = number of sampling dates. *Laboratory precision during 1969 was low. Data reported to nearest 0.1 mg/L phosphate; those values were within ±16 ug/L phosphorus.

trations appear to have fluctuated annually with no trend discernible.

Nutrient concentrations in Devils Lake are quite low (Table 5) and are among the lowest on record for lakes in the region (based on Lillie and Mason, 1983). Epilimnetic phosphorus concentrations generally increased from summer to fall (Table 6) as did hypolimnetic values (Figure 7). Increased hypolimnetic phosphorus concentrations were observed in 1981 and 1984. Volume weighted estimates of total in-lake phosphorus mass indicated an overall increase of 100-400 kg in the water column from early summer to fall turnover (Table 7). This corresponds with an observed average increase of 180 kg from spring to fall. However, spring phosphorus levels were consistently low (mean 15 ug/L) and no clear trend was evident in the 19 year record of epilimnetic phosphorus concentrations (Figure 8).

Lowest total nitrogen concentrations occurred during spring turnover (mean 0.35 mg/L) and highest levels occurred during the fall turnover (mean 0.47 mg/L). Occasional extreme values have been recorded in surface waters during late summer algae blooms (2.12 mg/L maximum), whereas higher

TABLE 7. Comparison of computed (estimated) mass of inlake total phosphorus for Devils Lake. Values in kilograms of phosphorus.

Years	*June*	*July*	*August*	*Sept.-Nov.*	*Sources*
1971-72		144-224	196	284	Stauffer, 1974
1974		140-205			Vignon and Armstrong, 1977
1978-80		265-303	255-583	243-278	DNR-BLP; WRR
1981	275	181	246	202	DNR-BLP
1982		140	186	291-337	DNR-DLSP
1983	191-192	216-218	240	240-296	DNR-DLSP
1984	149-165	N.S.	347	408-579	DNR-DLSP
1985	160	189	219		DNR-DLSP

Data Source Codes: DNR-BLP = Benchmark Lake Program
DNR-DLSP = Devils Lake State Park
DNR-WRR = Water Resources Research Section

levels were typically found in the hypolimnion. Epilimnetic nitrogen concentrations appeared to have increased steadily from 1967 to 1971 after which they appeared to have oscillated back and forth about the mean (Figure 9). No indications of further increases were evident. The lake appeared to be phosphorus limited as total nitrogen to phosphorus ratios generally exceeded 10:1.

Other commonly reported water quality parameters were relatively stable, both seasonally and by depth throughout the period of historical record. Values generally were lower than normal for the region (Table 8). No clear trends are apparent in any of these parameters during the period of record

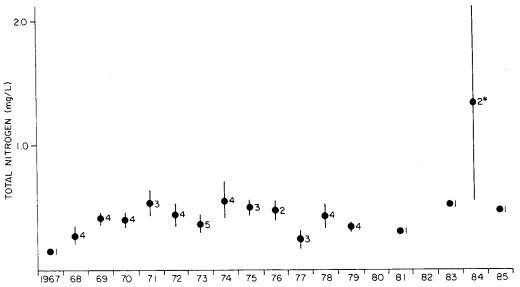

Fig. 9. Epilimnetic total nitrogen concentrations ($\bar{X} \pm$ 1SE) in Devils Lake during 1967-85. (N) = Number of sampling dates. *One extremely high value recorded during summer bloom in 1984.

TABLE 8. Average annual water chemistry values for Devils Lake. All values in mg/L unless otherwise noted.

Parameter	*N*	*Mean*	*SE*	*CV %*
Alkalinity	57	22	0.4	14
Calcium	48	7.5	0.4	33
Magnesium	48	4.5	0.3	46
Sodium	50	2.7	0.2	60
Potassium	49	1.3	0.1	55
Chlorides	53	2.2	0.1	34
Conductivity**	45	88	2.1	16
PH[a]	65	7.3*	0.03	3

* Arithmetic mean.
** umhos/cm
[a] pH units

(Figure 10). Magnesium concentrations appeared to have more than doubled from 3 to 8 mg/L during 1967 to 1980 but the most recent data (1983-85) were similar to the earliest data. Conductivities have been quite variable but appeared to have been higher than normal during 1979.

Historical Record—Fish

The fish population of Devils Lake represents the pinnacle of the food chain and as such has exerted a great ecological impact on the lake. What the "original" population was like before any human manipulations took place is unknown, but a population of forage, panfish and game fish species similar to that of other southern Wisconsin lakes (Becker, 1983) probably existed in presettlement times. Because of the lake's geologic history, its fish population most likely originated from the Wisconsin River drainage system. Early settlers may have found lower standing crops of fish than in other lakes in southern Wisconsin due to the unique morphometric characteristics and relatively low fertility of the lake.

Historical records show 32 different fish species caught, observed, or stocked in Devils Lake between 1866-1985 (Table 9); while past errors in identification cannot be ruled out, data given in Table 15 are believed to be reasonably accurate.

Earliest records on the fish species inhabiting Devils Lake and early accounts of fish stocking were gleaned from local newspapers by Ken Lange, Devils Lake State Park Naturalist. The *Baraboo Republic* reported that the lake in 1866 had great numbers of "perch, bass and pickerel, some of the latter weighing twenty-five pounds." The species of "bass" referred to here is uncertain, but the "pickerel" weighing 25 pounds were surely northern pike. An undated brochure on the Cliff House, a resort on Devils Lake from 1873-1904 lists "pike, pickerel, black bass, yellow perch, sunfish and minnows" as present in the lake. Again, whether the "black bass" were largemouth

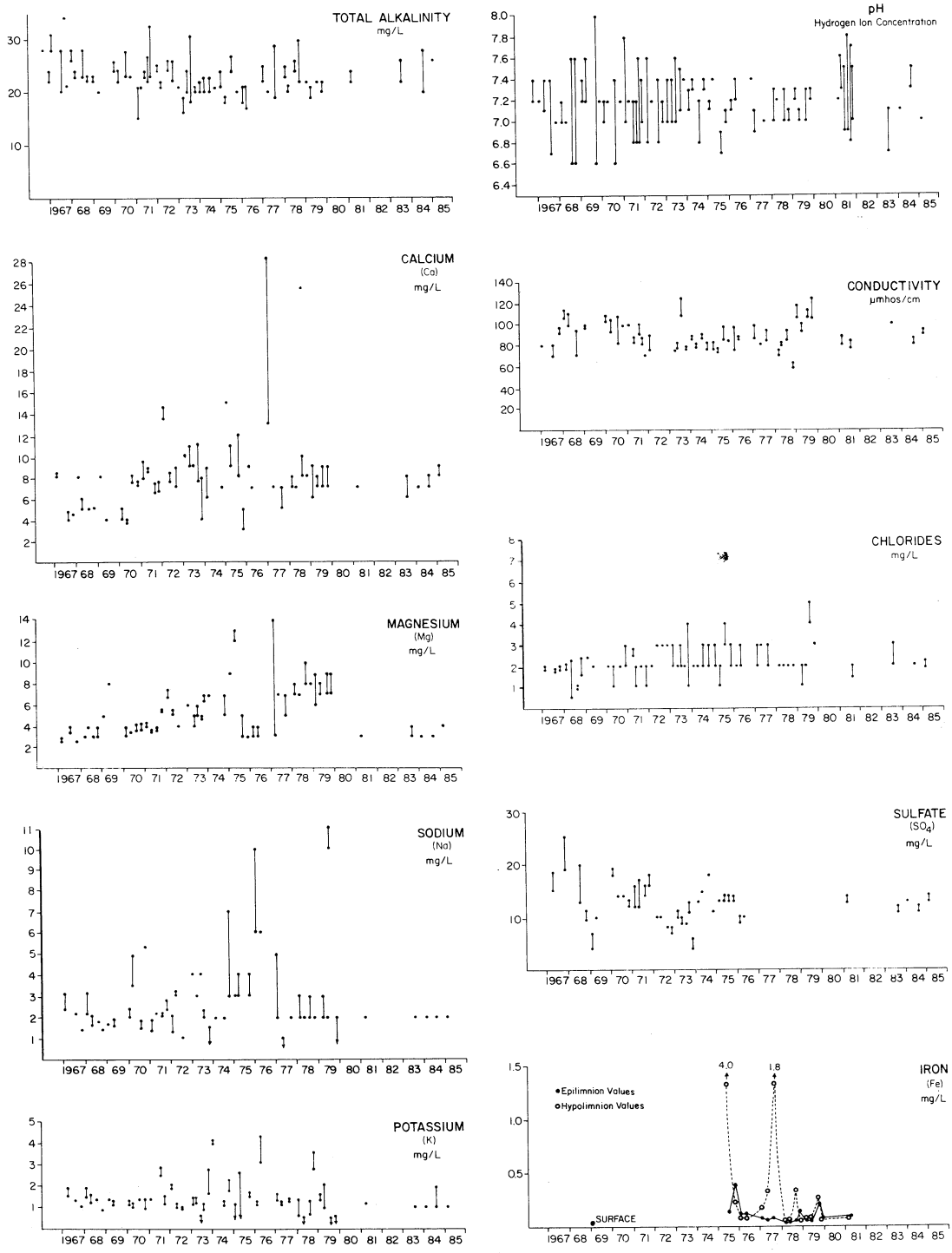

Fig. 10. Historical trends in selected water chemistry parameters for Devils Lake during 1967-85. Ranges for surface and hypolimnetic sample values are given for: a) total alkalinity, b) calcium (Ca), c) magnesium (Mg), d) sodium (Na), e) potassium (K), f) pH, g) conductivity, h) chlorides (Cl), i) sulfate (SO_4), and j) iron (Fe).

TABLE 9. Historical record of fish species inhabiting or introduced into Devils Lake. Numbers indicate information source, S denotes stocked fish; stocking records after 1944 not included.

Species	1866	1873	1875	1878	1879	1884	1885	1894	1895	1896	1897	1904	1905	1906	1912	1922	1925-28	1931	1934	1935	1937	1938	1939-44	1945	1947	1948	1954-55	1967	1968-70	1972	1974	1978	1984-85
White Sucker *Catostomus commersoni*					1						1	1	1				7		6							9	10			13	14		16
Mimic shiner *Notropis volucellus*																	7																16
Bluntnose minnow *Pimephales notatus*																	7																16
Northern pike *Esox lucius*	1						1										7						8 S	8			10	11	12	13	14		16
Yellow perch *Perca flavescens*	1						1		1								7			8 S				8		9	10	11	12		14		16
Walleye *Stizostedion vitreum*						1 S	1										7			8 S	6 S	8 S		8			10		12	13	14		16
Iowa darter *Etheostoma exile*																	7																16
Smallmouth bass *Micropterus dolomieui*																	7			8 S		8 S					10	11	12				
Green sunfish *Lepomis cyanellus*																	7																16
Bluegill *Lepomis macrochirus*																	7		6 S	8 S	8 S	8 S		8			10	11	12		14		16
Rock bass *Ambloplites rupestris*							1										7							8			10	11	12	13	14		16
Black crappie *Pomoxis nigromaculatus*																	7			8 S	8 S						10	11	12				16
White crappie *Pomoxis annularis*																																	16
Fathead minnow *Pimephales promelas*																												11					16
Spotfin shiner *Notropis spilopterus*																												11					16
Spottail shiner *Notropis hudsonius*																								8									
Blacknose dace *Rhinichthys atratulus*																																	16
Johnny darter *Etheostoma nigrum*																								8				11					16
Burbot *Lota lota*											1				1										3	9	10					15	

Species	1866	1873	1875	1878	1879	1884	1885	1894	1895	1896	1897	1904	1905	1906	1912	1922	1925-28	1931	1934	1935	1937	1938	1939-44	1945	1947	1948	1954-55	1967	1968-70	1972	1974	1978	1984-85
Pumpkinseed Lepomis gibbosus					1																							11	12				16
Largemouth bass Micropterus salmoides																					8 S	8 S	8 S			10	11	12	13	14		16
Brown bullhead Ictalurus nebulosus																										10						
Yellow bullhead Ictalurus natalis																																16
Carp Cyprinus carpio												1																				
White bass Monrone chrysops											2 S						6 S															
Rainbow trout Salmo gairdneri									1																	10	11	12		14		
Brown trout Salmo trutta																											11	12	13	14		
Brook trout Salvelinus fontinalis			4 S												1																	16
Channel catfish Ictalurus punctatus																														1		
Lake trout Salvelinus namaycush				1 S																												
Atlantic salmon Salmo salar			5 S																													
"Pike"									1									6 S	6 S	6 S												
"Bass" or "Black bass"	1						1	1 S	1	2 S	1	1 S	1 S						6 S													
"Sunfish"																								8								
"Bullhead"													2										8 S					12				
"Trout"		4 S																														

1. Newspaper, *Baraboo Republic*
2. Newspaper, *Sauk County Democrat*
3. Wisconsin Conservation Bulletin
4. Newspaper, *Milwaukee Sentinel*
5. Leopold, Aldo, *A Sand County Almanac*
6. Newspaper, *Baraboo Weekly News*
7. Greene, C. W., 1935. The Distribution of Wisconsin Fishes.
8. Wisconsin Conservation Department, Fish Management Rept. No. 86.
9. Cline, WCD memo on fish survey in 1948.
10. Jacob, WCD Invest. Memo, Nos. 225 and 226.
11. Meier and Ensign, DNR 1967 fish population survey.
12. Brynildson, Ives and Druckenmiller, DNR Bureau of Fish Management Rept. No. 35.
13. Smith, DNR memo on fish survey in 1972.
14. Kirschbaum, DNR memo on fish survey in 1975.
15. Barnhardt and Jameson, personal observations.
16. Mason, DNR memo on fish survey in 1984.

or smallmouth, or what species of "sunfish" or "minnows" were there is unknown. The "pike" were no doubt walleyes. Since the Cliff House brochure is not dated, some of the fish species mentioned could have been introduced into the lake through stocking, including walleyes. Based on old newspaper accounts, habitat requirements, and possible origins of fish species in Devils Lake, we believe white suckers, rock bass, burbot, pumpkinseed, darters, and shiners were probably original lake residents.

One thing is certain, stocking of the lake began at least as early as 1873 and some species not originally found there have been introduced to the lake. "Conservationists" of the late 1800's apparently recognized the clear waters of Devils Lake as potential trout habitat, since the first species reported stocked were salmonids, e.g. brook trout, lake trout, Atlantic salmon, and probably rainbow trout. Brook trout may have already been present in the lake before they were stocked; a native population might have inhabited the southwest inlet. The lake trout and Atlantic salmon stocked most likely quickly disappeared from the lake. Rainbow trout were first reported as present in the lake in 1895 but were probably stocked much earlier.

Conservation agency workers and cooperating sportsmen of the early era believed stocking and redistributing of fish in the state's waters were good management practices, and as Table 9 clearly shows, Devils Lake did not escape their "management." Species intentionally stocked in the lake includes some besides the salmonids which may not have been there originally. White bass in all likelihood were not native, yet they were stocked on at least two different occasions. Other species stocked, some of them many times, were largemouth and smallmouth bass, walleyes, northern pike, black crappies, bluegills, yellow perch, and bullheads. Of these stocked species, it appears relatively certain northern pike, yellow perch, and one of the basses (probably largemouth) were present in Devils Lake prior to stocking; stockings of some or all of the other species could have been intentional introductions. In addition to all these deliberate plantings, there certainly have been unintentional introductions of new species, in particular minnows used as bait by anglers.

The first comprehensive fish surveys in Devils Lake were made in the early 1900's by University of Wisconsin scientists. Greene (1935) reported on surveys made between 1925-1928, and examined collections made earlier by other investigators. He found 14 species, some of which had never been mentioned as present before that time. Since 1937, several studies of the fish population have been made by the Wisconsin Conservation Department/Department of Natural Resources and good records are available on fish stocking.

From 1944 to 1984, mostly walleye and trout were stocked. Trout stocking was generally viewed as very successful and provided a popular and productive fishery (Jacob, 1954 and 1955; Meier and Ensign, 1967; Brynildson, Ives, and Druckenmiller, 1970). Both rainbow and brown trout have been found to survive and grow well in Devils Lake but neither species has ever successfully reproduced there. Evaluation of the success or failure of walleye stocking program has been considerably more complicated, because naturally-reproduced walleyes also presumably exist in the lake. Walleye fishing reportedly has been good in some past years, but in recent years the walleye fishery apparently has declined, even though large numbers of walleyes were stocked.

Rough fish have apparently never been abundant in Devils Lake. White suckers are believed to have been native to the lake and were taken in early years by seining and spearing when they congregated during the spawning season. Suckers have also been captured when fish population surveys were made but never in large number except in

May, 1955, when Jacob removed 4,456 pounds from the lake. The presence of carp in Devils Lake has been noted by personal observations, but carp have never been collected during any of the fish surveys. The current status of this species is uncertain but if carp are now present it is in low numbers.

There is very little historical record of the minnow population in Devils Lake aside from a few notations of species present. Greene (1935) reported mimic shiner, bluntnose minnow, and Iowa darter as found in the lake. In 1945, minnow seining by the Wisconsin Conservation Department caught "predominately spot-tail shiner and Johnny darter." Meier and Ensign (1967) listed bluntnose minnow, fathead minnow, spottail shiner, and Johnny darter as present. Smith (1972) reported seeing "many" fathead minnows. The October, 1984, fish population survey captured great numbers of minnows, with mimic shiner, spotfin shiner, and bluntnose minnow most abundant. Other species present in lesser numbers were Iowa darter, Johnny darter, fathead minnow, and blacknose dace. Based on this information, there appears to have been some changes in minnow population composition and abundance since the early 1900's which could have an important ecological impact.

Population surveys made over the past 30 years by Jacob (1954, 1955), Meier and Ensign (1967), and Mason (1984) suggest that the fish composition of Devils Lake has changed (Table 10). These surveys indicate increases in the bluegill, pumpkinseed, and largemouth bass populations and possible decreases in perch, walleye, and smallmouth bass numbers between 1955-1984. Northern pike and black crappie numbers also may have increased during this period. The greatest increase in the largemouth bass population appears to have occurred between 1955-1967, while the greatest proliferation of the bluegill-pumpkinseed population apparently took place between 1967-1984.

The bluegill-pumpkinseed population expansion is the most dramatic and potentially ecologically significant fish population change. Newspaper records from the late 1800's do not mention bluegills and only one account mentioned pumpkinseeds (*Baraboo Republic,* July, 1879). Greene (1935) and other associated scientists captured bluegillls during their surveys of Devils Lake in the early 1900's, providing the first record of

TABLE 10. Comparison of catch of some warm-water fish species by netting surveys of Devils Lake.

Survey Date:	*May, 1954 (Jacob)*	*Apr.-May, 1955 (Jacob)*	*Sept., 1967 (Meier-Ensign)*	*October, 1984 (Mason)*
Gear and effort:	*2,250 foot seine, 2-3 in. mesh, 4 hauls. Dougle end drop net, 2 in. mesh, 8 days.*	*2,250 foot seine, 2-3 in. mesh, 5 hauls. 5 test nets, 2 in. mesh, 3 days.*	*2,100 foot seine, 1.5-2.5 in. mesh, 2 hauls.*	*1,300 foot seine, 1.5 in. mesh, 2 hauls.*
Species—No. Caught				
Bluegill	79	52	698	3,129
Pumpkinseed	0	0	22	540
Yellow perch	1,226	531	8	174
Rock bass	0	78	3	19
Black crappie	0	13	9	182
Largemouth bass	2	0	717	799
Smallmouth bass	27	29	4	0
Walleye	22	232	0	1
Northern pike	19	33	39	67

TABLE 11. Mean length of different age groups of fish species in Devils Lake compared to averages for other Southern Wisconsin lakes. Sample nos. in parentheses.

		Devils Lake Surveys					*Southern Wisconsin Averages*	
		Jacob May, 1954	*Jacob Apr.-May, 1955*	*Meier-Ensign Sept., 1967*	*Mason Oct., 1984*	*Mason May, 1985*	*Mackenthun 1949*	*Druckenmiller 1972*
Species — Age Group								
Bluegill — Age	0*				1.4(173)			
	1	4.4(6)	4.4(1)	5.4(9)	3.0(4)		5.0(97)	4.7(266)
	2		6.3(10)	6.9(9)	5.4(5)		5.6(529)	5.4(749)
	3			7.5(2)	6.5(12)	5.1(19)	6.4(1424)	6.2(930)
	4	8.5(1)	8.6(2)	8.3(3)	7.1(9)	5.9(39)	7.3(1170)	7.2(448)
	5			8.9(2)	8.3(8)	6.4(12)	8.0(422)	7.6(188)
	6		9.8(2)		8.9(7)	6.5(4)	8.8(109)	8.0(40)
Yellow perch	0*				2.7(191)			
	1				5.0(17)			5.6(4)
	2	6.4(4)	7.4(4)		6.7(21)		5.6(16)	7.5(44)
	3	7.5(3)	8.8(2)	8.3(1)	8.3(10)		7.6(190)	8.0(47)
	4		9.6(1)		9.6(11)		8.8(262)	8.4(23)
	5	9.8(5)	10.0(1)		10.7(2)		9.6(139)	
	6	11.8(3)	11.4(6)				11.1(39)	
Rock bass	0*				1.5(11)			
	1						5.2(3)	
	2				5.1(1)		5.5(61)	5.9(30)
	3		6.1(3)		6.8(3)	6.2(8)	5.8(278)	6.5(44)
	4		6.9(2)	7.9(1)	7.7(5)	7.2(16)	6.8(310)	7.8(30)
	5		7.9(1)		8.0(5)	7.4(13)	7.6(215)	8.8(25)
	6		8.5(2)			9.8(3)	8.5(72)	8.6(4)
	7		9.9(3)			10.9(1)	9.5(35)	
Black crappie	1			6.5(1)	4.9(2)		6.3(83)	5.4(116)
	2		9.7(1)	9.0(2)	7.8(28)	5.3(5)	7.2(434)	6.5(227)
	3			10.7(2)	9.3(27)	8.8(1)	7.8(708)	10.0(250)
	4		11.5(1)		11.0(7)		9.2(636)	9.5(121)
	5		11.9(1)				10.0(206)	10.5(61)
	6		13.1(5)					
Northern Pike	1	12.1(5)	13.7(1)	16.6(2)	16.2(27)			16.4(47)
	2	18.5(1)	20.2(9)	15.6(1)	21.0(10)		16.6(17)	18.7(75)
	3	23.8(3)	25.2(3)		22.9(5)		15.6(72)	22.8(44)
	4	26.5(1)	39.0(1)		24.0(1)		17.5(104)	25.6(35)
	5						20.3(102)	27.6(21)
	6				36.5(2)		22.8(83)	31.5(4)
	7		41.0(2)					
	8		41.0(2)					

* Age group 0 average length determined from length frequency.

bluegill presence in the lake. In the period from 1934-44, the Wisconsin Conservation Department repeatedly stocked bluegills, therefore, fish managers in the Department must have felt the population at that time was not providing an adequate fishery. Jacob's surveys in 1954 and 1955 indicate that the bluegill and pumpkinseed populations remained relatively low through that period, but when Meier and Ensign sampled the lake in 1967, the population increase apparently had begun. By 1968-1970, a creel census showed bluegills were the most numerous fish caught in Devils Lake, making up 39-57 percent of the catch (Brynildson, et al., 1970). The 1984 survey data (Mason) suggest the upward trend in the bluegill and pumpkinseed populations has continued to the present; 75 percent of the fish caught in the survey were bluegills and pumpkinseeds. Therefore the data indicates bluegill and pumpkinseed populations have historically been relatively low and stable in Devils Lake, but have increased greatly over the past 20-30 years.

Bluegill growth rate may have decreased as they became more abundant (Table 11). Early survey data indicate bluegills grew faster than normal for southern Wisconsin lakes. From the 1984-1985 age-length data, it appears growth rate may have slowed since 1954-1955. Length frequency data for bluegills captured in October, 1984 (Figure 11) show large numbers of small fish, with 88 percent in the 3-6 inch size range. These fish were of different overlapping age groups.

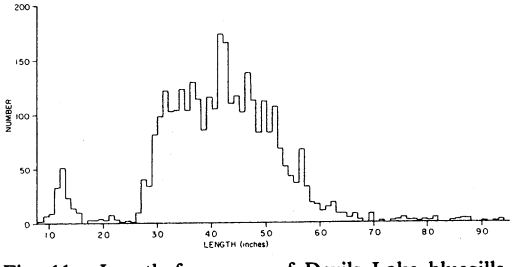

Fig. 11. Length frequency of Devils Lake bluegills, October, 1984.

Further, average length of 173 young of the year bluegills caught by shoreline seining in fall, 1984 was 1.4 inches, suggesting poor growth during the previous summer.

Lower condition factor of bluegills might also be anticipated as a result of population increase, but data limitations prevented valid statistical comparison of length-weight data from the fish surveys.

Growth rate of other panfish (yellow perch, rock bass, and black crappie) in Devils Lake remains average or above for southern Wisconsin lakes. Northern pike growth rate apparently has not changed over the past 30 years and is as good as, or better than, in other lakes in the region.

Historical Record—Macrophytes

A major change has taken place within the macrophyte community of Devils Lake. The aquatic plants of Devils Lake apparently received little attention prior to 1974, based on the recovery of only a few sketchy field notes or observations. While some collections of various shoreline emergents were made (Lange, 1984), and specimens undoubtedly exist in various herbariums throughout the state, no extensive vegetative survey of the submergent macrophyte community was accomplished until 1974 (Baker, 1975). While Baker's 1974 survey was limited to an area adjacent to the southeast beach area, it served as the foundation for assessing historical changes. Baker reported a plant community consisting of 7 species, dominated in number by *Potamogeton robbinsii* and in area by *Elodea canadensis.* Significant is his description of *Myriophyllum verticillatum* as "relatively scattered, at 1.2 to 4.5 m depths contributing little to the population of the total community." Unfortunately, and contrary to the cited paper, voucher specimens were not deposited in the University of Wisconsin herbarium and have since been lost (pers. comm. Baker). The identification of the milfoil species was confirmed by UW-Madison staff.

Systematic vegetation surveys were ini-

tiated by the WDNR in 1978 and were continued through 1983 (Bale and Molter, 1979, 1980, 1981; Bainbridge and Molter, 1982; Molter and Schlesser, 1983; annual surveys). These surveys documented the presence of several additional species including the dominance of *Nitella* sp. in deeper waters and the significant contribution of milfoil (species taxonomy in question) in shallower areas. Estimated areal coverages and distributions based on a grid overlay and rake samples showed minor fluctuations from year to year. Elodea was the most abundant species found in 1982 (Schlesser, Bainbridge and Molter, 1982).

An extensive survey of macrophyte distribution, composition, and dry weight biomass was conducted in 1984 by the Bureau of Research, Water Resources Research Section, Wisconsin DNR, (Lillie, 1986). Macrophytes covered 66 acres with an average density of 183 g/m^2 and total biomass of 51,000 kg (56 tons) dry weight. Sixteen macrophyte species were recorded (Table 12). *Potamogeton robbinsii* accounted for 50 percent of the total plant biomass while

TABLE 12. Aquatic macrophyte composition of Devils Lake (from Lillie, 1986).

	Percent Frequency (% Total Sites)	*Percent Total Biomass (% Total)*
Potamogeton robbinsii	40	46
Myriophyllum spicatum	35	20
Elodea canadensis	36	11
P. illinoensis and *P. amplifolius*	18	5
Ceratophyllum demersum	16	4
Nitella flexilus and *Cladophora* sp.	18	5
Other*	2	9

* Includes *Eleocharis acicularis, Najas* sp., *Vallisneria americana, Isoetes echinospora, Potamogeton diversifolius, P. crispus, P. pusillus,* and *Chara* sp.

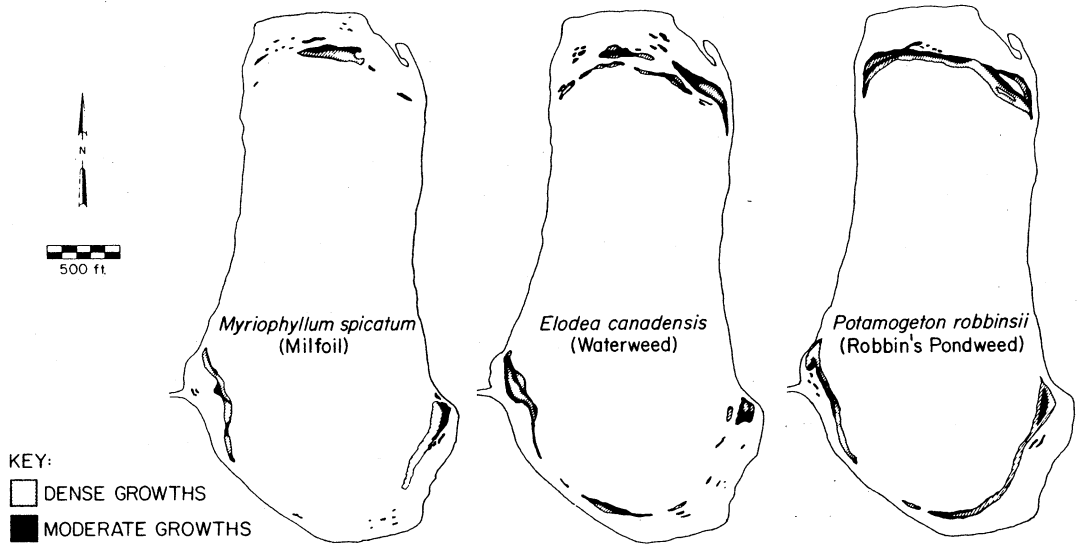

Fig. 12. Distribution of *Myriophyllum spicatum, Elodea canadensis,* and *P. robbinsii* within Devils Lake during summer 1984.

Myriophyllum spicatum and *Elodea canadensis* were next in order of importance. The distributions of these dominant species were depth dependent, forming generally contiguous bands about the lake perimeter (Figure 12). The milfoil beds extended to the surface at depths from 6-9 feet forming biological "barrier reefs" 80-160 feet wide and up to 1,000 feet long. Total milfoil acreage (7 acres) represented only 2 percent of the total lake acreage but stand densities were so dense (160-183 g/m² that the habitat structure was nearly impenetrable to divers.

Comparisons with Baker's 1974 (Baker, 1975) survey and with earlier DNR investigations, suggest that elodea has greatly declined, milfoil has greatly expanded, and *P. Robbinsii* has remained relatively unchanged within Devils Lake (Lillie, 1986). Average total biomass densities were quite similar to other fertile Wisconsin lakes (Table 13).

Historical Record—Plankton Data

The plankton community of Devils Lake is very important because of its relationship to water clarity, nutrient recycling and other biological populations. However, it has not been historically well documented.

The zooplankton record is extremely meager, consisting of only a few representative seasonal samples. The large-bodied cladoceran, *Daphnia pulicaria* and a calanoid copepod, *Epischura lacustris* have been observed in large numbers as recently as 1984. Recent collections included great numbers of smaller-bodied forms including the rotifers, *Kellicottia* sp. and *Polyarthra* sp., the cladoceran, *Bosmina* sp., and the appearance of an additional daphnia species, *D. dubia.*

The phytoplankton record is somewhat more substantial, but data are generally inadequate to draw definite conclusions. Earliest observations on phytoplankton composition were primarily of net plankton only, whereas the recent record includes the contribution of nannoplankton (Table 14). Although sampling frequency was low, the typical pattern of phytoplankton succession during the recent record was of spring

TABLE 13. Macrophyte biomass comparisons among Wisconsin lakes. Biomass based on density per m² of colonized area unless otherwise noted.

Reference	*Lake*	*# Species*	*Dry wt. g/m²*	*Notes*
Wilson (1941)	Trout Lake	36	0.075	
Wilson (1935)	Silver (Sparkling)	15	0.08	
Wilson (1935)	Muskellunge	33	0.45	
Wilson (1935)	Little John	12	0.52	
Rickett (1922)	Green Lake	27	178	
Rickett (1924)	Lake Mendota	16	202	
Sefton (1977)	Mississippi R. Pool #8	—	182	
Caflin (1977)	Mississippi R. Pool #7	—	179	In Sefton (1977)
Engel (1984)	Cox Hollow	—	100-300	0.5 + 1.5A
Engel (1984)	Halverson	15	150-300	Preharvest
Engel and Nichols (1984)	Marion Millpond	—	600	Disturbed areas
Lillie (1986)	Devils Lake	16	169-259	Dense Beds
			183	All colonized areas
			1,294	Max. per sample (2.4m depths, milfoil dominant)

TABLE 14. Summer phytoplankton associations—Devils Lake, Sauk County.

	Dominant Phytoplankton	
	By Groups	*By Major Genera*
1907	Desmid—Bluegreen	Staurastum, Anabaena, Gloeotrichia
1908	Bluegreen—Pyrrhophte	Gloeotrichia, Ceratium
1909 (early)	Bluegreen—Desmid	Gloeotrichia, Staurastrum,
(late)	Pyrrhophyte—Bluegreen	Ceratium, Nostoc
1913	Bluegreen	Gloeotrichia, Microcystis
1914-17*	Chrysophyte—Desmid	Dinobryon, Cosmocladium
1915 (late)	Bluegreen—Diatom	Anabaena, Tabellaria, Fragilaria
1923	Bluegreen	Aphanocapsa
1972	Green	(not given)
1977	Bluegreen	Aphanizomenon
1978	Cryptophyte	Chroomonas
1979	Cryptophyte—Bluegreen	Chroomonas, Aphanothoce, Aphanizomenon
1980	Bluegreen	Anabaena
1982	Bluegreen	Gloeotrichia, Anabaena and Aphanizomenon
1983	Bluegreen and Cryptophytes	Anabaena
1984	Bluegreen	Anabaena, Gloeotrichia (Some Ceratium)

Data Sources: (1907-09, 15 and 23) Birge and Juday—UW Archive material
(*1914-17) Smith, 1920
(1972) Stauffer, 1974
(1977-84) Last, unpublished DNR collection data

TABLE 15. Devils Lake Chlorophyll *a* data, 1971-1985.

Year (Source)	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*
1971 (Stauffer, 1974)			2	2				
1972 (Stauffer, 1974)	3	1[2]	1[3]			12		
1974 (Vignon & Armstrong, 1977)	3[4]	1[4]	1[4]	1[2]				
1977 (DNR-WRR)					7			
1978 (DNR-WRR)	7				3			
1978 (DNR-BLP)					2[2]	3-6		
1979 (DNR-WRR)					6			6
1979 (DNR-BLP)		5-11	1[2]	5[2]		3	2-3	
1980 (DNR-BLP)	4	2	5	5[2]	4-5	10-15		
1981 (DNR-BLP)		2	1-2	2-4	6[2]	9-14		
1982 (DNR-DLSP)				2	5	2	43	22
1983 (DNR-DLSP)		4[2]	5	2[2]	4-5	20	9	11
1984 (DNR-DLSP)	5-6	10			6-36	13-20	13-20	10
1985 (DNR-DLSP)	7	2[2]	2-3	2[2]				

Note: Some liberties were taken in rounding-off chlorophyll values to the nearest whole ug/L. Superscript numbers refer to multiple samples within same month.

Data Source Codes: DNR-BLP = Benchmark Lake Program
DNR-DLSP = Devils Lake State Park
DNR-WRR = Water Resources Research Section

diatom blooms followed by late summer and early fall bluegreen blooms. Diatoms returned as dominants in late fall. Sampling was insufficient to characterize winter composition.

The bluegreen, *Aphanozomenon flos-aqua,* did not become an important component of the late summer bloom until 1977 and has occurred only sporadically since then. *Gloeotrichia enchinulata,* a colonial filamentous bluegreen and major dominant in the early record, was missing from the recent record until 1982 when it was a major dominant after an absence of nearly 70 years.

Chlorophyll *a* concentrations were less than 10 ug/L during spring and summer corresponding to good water quality conditions (Lillie and Mason, 1983). Concentrations increased steadily in late summer or early fall, and then declined as water temperature cooled. Occasional spring diatom blooms were generally of much less consequence than the fall blooms. The historical chlorophyll *a* data base is very limited as this parameter has only recently been routinely measured (Table 15). The mean concentration has been 5.9 ±0.8 ug/L for 88 observations. Data are insufficient to determine long-term trends.

Discussion

The impetus which led to this study of water quality conditions in Devils Lake was the general concensus of opinion among individuals who were well acquainted with the lake that water quality had deteriorated or was in the process of deteriorating. A careful and detailed examination of the available data, both quantitative and qualitative, has lead us to conclude that some compositional changes have occurred in the biota. While no conclusive evidence was found in the data to suggest a permanent change in water quality, the biotic changes noted could be related to or lead to water quality changes.

Devils Lake appears to be better protected now than it was formerly against degradation from its watershed. External nutrient loading to the lake has most likely decreased in recent years. It is estimated that the permanent diversion of the northeast subbasin drainage resulted in a 40 percent reduction in annual watershed loading. The purchase and removal of lakeside cottages and purchase by the state of private agricultural lands, with subsequent reversion to natural vegetative cover, should likewise result in reduced loadings via run-off. External inputs via park users have probably increased, but their combined quantitative input was estimated to be minimal. There are no data on loading via direct precipitation.

The aesthetic appearance of Devils Lake is a major factor contributing to the lake's value and popularity. Water transparency and color are two critical components influencing the appearance of the lake. Color is influenced by dissolved and suspended materials and light reflection off bottom substrates. Transparency is dependent on the amounts of inorganic and organic suspended materials contributing to turbidity, on phytoplankton biovolume (estimated by chlorophyll *a* concentration) and on color. Based on a random survey of 661 Wisconsin lakes, those which appeared blue or clear generally had low chlorophyll *a* concentrations (less than 10 ug/L) and good water clarities (Lillie and Mason, 1983). Therefore, the perceived changes in water appearance observed by the public would seem to point to a change in general trophic condition. The available record of water clarity measurements seems to substantiate this perception, since the reduced water clarities in the late 1970's and early 80's coincide with the subjective observations. However, the most recent record suggests that these fluctuations in water clarity may be only temporal in nature and conditions may revert to a pre-1976 state. With only limited data available, it is not possible to determine whether a water clarity trend has developed or the changes noted in Devils Lake are within normal variability. Even with a much

larger data base, water clarity trends in lakes are difficult to document, as Stewart (1976) demonstrated in his work on the Madison lakes.

As with the reduction in water clarities, the reductions in hypolimnetic oxygen concentrations observed during 1976-81 appear also to have been temporal. These anomalies may have resulted from a combination of external and internal factors. Climatic variability influences annual and seasonal nutrient loading to the lake, the duration and timing of spring and fall overturns (onset of thermocline establishment), and rate and timing of thermocline erosion. All of these factors have been demonstrated to play an important role in nutrient cycles and subsequent water quality conditions (Lund, 1972; Stauffer and Armstrong, 1984; Stauffer, 1974). In addition, variations in hydrologic loading contributed to the fluctuations in water level previously noted. These variations in water level affect the area of the lake bottom exposed to mixing and resuspension of sediments and influence the concentrations of various water chemistry parameters including hypolimnetic oxygen.

Reduced water levels and aberrations in the late summer weather pattern (i.e. early severe cold spells) could have influenced the thermocline migration mechanism (Stauffer, 1974) and contributed to early onset of phytoplankton blooms, declines in water clarity, and increases in the hypolimnetic oxygen deficit rate in some years. However, an important distinction is that while similar climatic conditions may have existed in earlier years when water levels were the same or even lower, similar reductions in water quality were not observed. Undoubtedly thermocline migration does occur in Devils Lake and it theoretically could account for much of the observed progressive increases in epilimnetic phosphorus and chorophyll *a* concentrations late in the summer. However, it does not account for the differences noted in water clarity in early summer. These differences may be due to the combined affects of climate on thermocline establishment and on diatom bloom dynamics, or on other unidentified interrelationships.

Changes in Devils Lake biota were documented which could be the result of, or could result in, changes in trophic state of the lake. *Aphanizomenon flos-aqua,* a filamentous bluegreen algae typically found in enriched trophic situations, was first observed in 1977. *Myriophyllum spicatum,* a European macrophyte, appeared in the lake sometime prior to 1974 and since has greatly expanded. The fish community has experienced a shift from the "cool water" walleye-smallmouth bass-perch population type to dominance by largemouth bass and bluegills. Also, changes in the minnow population have taken place. These biological changes, individually or in concert, could have contributed to the observed variations in water quality.

The invasion of milfoil in particular may have been a major factor. Milfoil grows in dense stands with stems and shoots reaching from the bottom to the surface at depths up to ten feet. As such, this represents a significant change in the structure of the submerged plant community of Devils Lake. Two roles are suspected of milfoil. First, the structure of the milfoil beds created a new habitat for fish that did not exist in Devils Lake prior to the invasion. The beds may serve as excellent refuges for small fish from predation by the large bass population prowling the exterior of the beds. The milfoil, by virtue of its very intricate dissected leaf structure, may harbor numerous invertebrates, thus serving as an alternative food source for the smaller fish which might normally depend upon the extensive zooplankton food resources available in the more exposed pelagic zone. Thus, milfoil beds may serve to provide both food and refuge to bluegills and pumpkinseeds, which were formerly extensively harvested by predator bass and northern pike. Changes in fish community structure due to vegetational structure have been well documented

elsewhere (Wegner et al., 1983; Crowder and Cooper, 1982; Savino and Stein, 1982; and Jaeger, 1985). Therefore, the proliferation of the panfish population could be related to the invasion of the Eurasion water milfoil. The second role milfoil may have served was in the acceleration of the internal nutrient cycling rate within the littoral zone. Studies have documented that milfoil may transport nutrients from underlying sediments to the overlying water column through root uptake, stem growth and subsequent sloughing, death and lysis of plant shoots, stems and leaves (Smith, 1979; Barko and Smart, 1979; Landers, 1982). A gross estimate of the calculated input of phosphorus to the lake during the summer period based on Prentki's 1979 work on Lake Wingra shows that this mechanism might account for as much as 40 percent of the observed seasonal increase of phosphorus from spring to fall.

Additional biological influences, such as zooplankton-phytoplankton interactions (Shapiro and Wright, 1984), or hypolimnetic phosphorus retrieval by phytoplankton (Salonem, Jones and Arvola, 1984) have not been sufficiently explored in Devils Lake and are also possible contributers to water quality variability.

Because Devils Lake is a seepage lake with no outlet, nearly all phosphorus entering the lake is retained. Therefore, continued phosphorus inputs to the lake would be expected to result in a gradual buildup of phosphorus within the lake or its sediments. However, the 19 year record of annual phosphorus concentrations shows no trend toward such an increase, nor was any change noted in the spring total phosphorus concentrations. Some mechanisms apparently are functioning to remove phosphorus from the water column in Devils Lake; one of these could be iron-phosphorus co-precipitation during mixing.

Conclusions

The subjective view that water quality has declined in Devils Lake appears related to subtle changes in water color and clarity during the peak summer usage period. Because these conditions have not always developed in past years even when similar climatic and hydrologic conditions existed (including water levels), the decline in water quality which may have occurred is masked by inherent variability. Climatic variations, fluctuating water levels, an increase in internal recycling, and changes in the lake's flora and fauna are the primary suspected causes for the periodic declines in water clarity that have been observed.

Studies have been initiated to further investigate trophic interactions in Devils Lake. Wise management of this valuable resource will depend on gaining a better understanding of ecological relationships in the lake system.

Acknowledgements

We acknowledge the work of the many Devils Lake investigators who preceded us and sincerely hope we have not omitted anyone's contribution in this historical data analysis. Our thanks go to all the DNR personnel who assisted us with recent data collection efforts, but especially to Devils Lake State Park staff for their cooperation. Funding assistance for data collection came from the Bureau of Parks and Recreation, and the DNR Lake Management program provided funds for publication of this report.

Literature Cited

Baker, F. C. 1975. The littoral macrophyte vegetation of southeastern Devils Lake. Trans. Wis. Acad. Sci., Arts and Lett. 63:66-71.

_____.Personal communication on November 29, 1985.

Bale, S., and C. Molter. 1979. Macrophyte survey Devils Lake—1974. Wis. Dept. Nat. Resour. Southern District, Rept. 8 pp (mimeo).

_____ and _____. 1980. Macrophyte survey Devils Lake—1980. Wis. Dept. Nat. Resour. Southern District, Rept. 8 pp. (mimeo).

_____ and _____. 1981. Macrophyte survery Devils Lake—1981. Wis. Dept. Nat. Resour. Southern District, Rept. 13 pp (mimeo).

Barko, J. W., and R. M. Smart. 1979. The role of *Myriophyllum spicatum* in the mobilization of sediment Phosphorus. In "Aquatic Plants, Lake Management and Ecosystem Consequences of Lake Harvesting," pp. 177-190. (Proceedings of conference at Madison, Wis., Feb. 14-16, 1979). J. E. Breck, R. T. Prentki, and O. L. Loucks, eds. Pub. by Center for Biotic Systems, Inst. Environ. Studies, Univ. Wis.-Madison.

Barnhardt, A. and D. Jameson. 1978. Personal observations of *Lota lota* in Devils Lake.

Becker, G. C. 1983. Fishes of Wisconsin. Univ. Wis. Press, Madison. 1052 pp.

Birge, E. A. and C. Juday. 1907-13, 15, 23. Unpublished file data in Univ. Wis. Archives.

Brynildson, C. L., D. B. Ives and H. S. Druckenmiller. 1970. A two-year creel census of Devils Lake, Sauk County. Wis. Dept. Nat. Resour., Bur. Fish Mgt. Rept. No. 35.

Claflin, ____. 1976. Unpublished data in Sefton, 1977.

Cline, C. L. 1945. Wis. Cons. Dept. memo filed Wis. Dept. Nat. Resour. Tech. Lib.

Conway, C. J. 1972. Oxygen depletion in the hypolimnion. M.S. thesis—water chemistry, Univ. Wis.-Madison.

Crowder, L. B. and W. E. Cooper. 1982. Habitat structural complexity and the interaction between bluegills and their prey. Ecology. 63(6):1802-1813.

Dillon, P. J. 1975. The application of the phosphorus-loading concept to eutrophication research. Sci. Ser. No. 46. Inland Waters Directorate, Canada. Center for Inland Waters, Burlington, Ontario. 14 pp.

Druckenmiller, H. S. 1972. Updated age-length averages for southeastern Wisconsin game fishes. Wis. Dept. Nat. Resour., Bur. Fish Mgmt. Rept. No. 55. 5 pp.

Dunst, R. 1975. Unpublished file data, Water Resources Research Section, Bureau of Research, Wis. Dept. Nat. Resour., Fitchburg, Wisconsin.

Engel, S. 1984. Evaluating stationary blankets and removable screens for macrophyte control in lakes. J. Aquat. Plant Manage. 22:43-48.

_____ and S. A. Nichols. 1984. Lake sediment alteration for macrophyte control. J. Aquat. Plant Manage. 22:38-41.

Greene, C. W. 1935. The distribution of Wisconsin fishes. Wis. Cons. Comm., Madison. 235 pp.

House, L. B. 1985. Stage fluctuations of Wisconsin lakes. Wis. Geol. and Nat. Hist. Surv., Information Circular No. 49.

Jacob, B. L. 1954. Test netting and seining survey of Devils Lake, Sauk County. Wis. Cons. Dept., Invest. Memo No. 225.

_____. 1955. Test netting and seining survey of Devils Lake, Sauk County. Wis. Cons. Dept., Invest. Memo No. 226.

Jaeger, J. 1985. Effects of recent ecosystem changes on Lake Wingra bluegills. Trans. Wis. Acad. Sci., Arts and Lett. 73:160-166.

Keast, A. 1984. The introduced aquatic macrophyte, *Myriophyllum spicatum,* as habitat for fish and their invertebrate prey. Can. J. Zool. 62:1289-1303.

Kirschbaum, D. 1975. Boom shocker survey of Devils Lake, Sauk County. Wis. Dept. Nat. Resour. memo.

Landers, D. H. 1982. Effects of naturally senescing aquatic macrophytes on nutrient chemistry and chlorophyll *a* of surrounding waters. Limnol. Oceanogr. 27(3):428-439.

Lange, K. I. 1984. Botanists and naturalists at Devils Lake State Park, Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 72:117-129.

Last, R. (N.D.) Unpublished phytoplankton data from various collections, Wis. Dept. Nat. Resour.

Leopold, A. 1949. Sand County Almanac. Oxford Univ. Press, N.Y. 226 pp.

Lillie, R. A. 1986. The spread of eurasian watermilfoil *Myriophyllum spicatum* in Devils Lake, Sauk County, Wisconsin. *In* Proceedings North Amer. Lake Mgt. Soc. Mtg., Intern. Symposium on Applied Lake and Watershed Management, held Nov. 13-16, 1985, Lake Geneva, Wis.

_____ and J. W. Mason. 1983. Limnological characteristics of Wisconsin Lakes. Wis. Dept. Nat. Resour. Tech. Bull. No. 138. 116 pp.

Lund, J. W. G. 1972. Changes in the biomass of blue-green and other algae in an English lake from 1945-69. *In* First Intern. Symp. on Taxonomy and Biology of Blue-Green Algae. pp. 305-327. (Held at Madras, Jan. 8-13, 1970).

Mackenthun, K. M. 1949. Age-length and length-weight relationship of southern area lake fisheries. Wis. Cons. Dept., Fish Invest. Rept. #586. 8 pp.

Martin, L. 1916. The physical geography of Wisconsin. Wis. Geol. and Nat. Hist. Surv., Bull. No. 36, Education Series No. 4. Madison, WI.

Martin, R. 1980. Unpublished file data. Water Res. Mgt., Wis. Dept. Nat. Resour., Madison, Wisconsin.

Mason, J. W. 1984. Devils Lake survey, October, 1984. Wis. Dept. Nat. Resour. memo.

Meier, H. and A. Ensign. 1967. Lake inventory—Devils Lake, Sauk County. Wis. Dept. Nat. Resour. memo.

Molter, C. and R. Schlesser. 1983. Devils Lake macrophyte survey. Wis. Dept. Nat. Resour.—Southern District. Rep. 8 pp. (mimeo).

Prentki, R. T. 1979. Depletion of phosphorus from sediment colonized by *Myriophyllum spicatum* L. *In* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting. pp. 161-176. (Proceedings of conference at Madison, Wis., February 14-16, 1979.) J. E. Breck, R. T. Prentki, and O. L. Loucks, eds. Center for Biotic Systems, Inst. Environ. Studies, Univ. Wis.-Madison.

Rickett, H. W. 1922. A quantitative study of the larger aquatic plants of Lake Mendota. Trans. Wis. Acad. Sci., Arts and Lett. 20:501-527.

_____. 1924. A quantitative study of the larger aquatic plants of Green Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 21: 381-414.

Salonen, K., R. I. Jones and L. Arvola. 1984. Hypolimnetic phosphorus retrieval by diel vertical migrations of lake phytoplankton. Freshwater Biology. 14:431-438.

Savino, J. F. and R. A. Stein. 1982. Predator-prey interaction betgween largemouth bass and bluegills as influenced by simulated submersed vegetation. Trans. Amer. Fish Soc. 111:255-266.

Schlesser, R. A. 1977-81. Unpublished file data. Water Resour. Mgt., Wis. Dept. Nat. Resour., Dodgeville Area.

_____, T. Bainbridge and C. Molter. 1982. Macrophyte survey Devils Lake—1982. Wis. Dept. Nat. Resour. Southern District, Rept. 15 pp (mimeo).

Sefton, D. F. 1977. Productivity and biomass of vascular hydrophytes on the upper Mississippi. *In* Wetlands-Ecology, Values, and Impacts, pp. 53-61. (Proceedings of the Waubesa Conference on Wetlands, Madison, Wis., June 2-5, 1977). C. B. Dewitt and E. Soloway, eds. Inst. Envir. Studies, Univ. Wis.-Madison.

Smith, C. 1979. Phosphorus and nitrogen content and uptake by macrophytes. *In* Synthesis Report on the Efficiency and Potential Consequences of Macrophyte Harvesting in Lake Wingra. pp. 91-104. Working paper for February 14-16, 1979, conference on the efficacy and impact of intensive plant harvesting in lake management. Center for Biotic Systems, Instit. Environ. Studies, Univ. Wis.-Madison.

Smith, G. M. 1920. Phytoplankton of Wisconsin. Vol. I. Wis. Geol. and Nat. Hist. Surv., Bull. No. 57, Sci. Series No. 12.

Smith, T. 1972. Boom shocker survey—Devils Lake, Sauk County. Wis. Dept. Nat. Resour. memo.

Stauffer, R. E. 1974. Thermocline migration-algal bloom relationships in stratified lakes. Univ. Wis.-Madison, PhD thesis. 526 pp.

_____ and D. E. Armstrong. 1984. Lake mixing and its relationship to epilimnetic phosphorus in Shagawa Lake, Minnesota. Can. J. Fish. Aquat. Sci. 41:57-69.

Stewart, K. M. 1976. Oxygen deficits, clarity and eutrophication in some Madison lakes. Int. Rev. Hydrobiol. 61(5):563-579.

U.S. EPA. 1980. Modeling phosphorus loading and lake response under uncertainty: a manual and compilation of export coefficients. EPA 440/5-80-011. 214 pp.

Uttormark, P. D., and M. L. Hutchins. 1980. Input/output models as decision aid for lake restoration. Water Resour. Bull. 16(3): 494-500.

Vignon, B. W., and D. E. Armstrong. 1977. The role of silica and the vernal diatom bloom in controlling the growth of nuisance algal populations in lakes. Tech. Completion Report, Project No. OWRT A-061-WIS, Univ. Wis. Water Resour. Center, Madison, Wis. 116 pp.

Vollenweider, R. A. 1975. Input/output models with special reference to the phosphorus loading concept in limnology. Schweiz. z. Hydrol. 37:53-84.

Werner, E. E., G. G. Mittelback, D. J. Hall and J. F. Gilliam. 1983. Experimental tests of optimal habitat use in fish: the role of relative habitat profitability. Ecology 64(6):1525-1539.

_____, J. F. Gilliam, D. J. Hall and G. G. Mittelbach. 1983. An experimental test of the effects of predation risk on habitat use in fish. Ecology 64(6):1540-1548.

Wilson, L. R. 1935. Lake development and plant succession in Vilas County, Wisconsin. Ecol. Monogr. 5:207-247.

_____. 1941. The larger aquatic vegetation of Trout Lake, Vilas County, Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 33:135-146.

Wisconsin Cons. Dept. 1945. Fish Mgt. Rept. No. 86, Wis. Dept. Nat. Resour. Tech. Lib.

Wisconsin Cons. Bull. 1948. Lawyer appetites. Vol. 13, No. 4, p. 31.

Wisconsin Department of Natural Resources. 1981. Trends in Devils Lake Water Quality—Subcommittee Report. Memo to R. H. Weber, Chairman, Devils Lake Water Quality Committee, dated June 16, 1981. 7 pp.

Wisconsin Department of Natural Resources. Unpublished file data collected by Devils Lake State Park staff, Baraboo, Wis.

Wisconsin Department of Natural Resources. Unpublished file data collected under the Benchmark Lake Program, Water Resour. Mgt., Madison, Wis.

Wisconsin Department of Natural Resources. Unpublished file data collected by Water Resour. Res. Sect., Bureau of Res., Fitchburg, Wis.

SUPPLEMENTAL DISTRIBUTION RECORDS FOR WISCONSIN TERRESTRIAL GASTROPODS

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The publication of distribution maps for the terrestrial gastropod fauna of the Eastern United States (Hubricht, 1985) is a milestone in determining probable ranges and focusing on where there may be actual distribution gaps or simply a lack of collecting.

As an aid to those who may wish to expand knowledge of the Wisconsin fauna, the following list of supplemental county records has been prepared from the mollusk collection of the Milwaukee Public Museum. The sequence of species follows Hubricht (1985). New county records for a total of 53 species are given including 15 new state records. Mr. Leslie Hubricht graciously consented to confirm these records by examining the specimens, and all the following records are accepted by Mr. Hubricht as being accurate.

I am very grateful to Mr. Leslie Hubricht, Meridian, Mississippi, for checking the identifications; to Alan Solem, FMNH, Chicago, for reviewing the manuscript; and my fellow workers at the Milwaukee Public Museum for all the assistance they have provided.

CARYCHIIDAE

Carychium exile exile H. C. Lea, 1842 Fond du Lac, Lafayette, Milwaukee, Ozaukee.

Carychium exiguum (Say, 1822) Marquette, Milwaukee, Ozaukee.

COCHLICOPIDAE

Cochlicopa lubrica (Muller, 1774) Milwaukee, Waukesha.

Cochlicopa lubricella (Porro, 1838) Jefferson, Milwaukee, Sauk, Washington, Waupaca, Winnebago; not recorded from Wisconsin in Hubricht (1985).

Cochlicopa nitens (Gallenstein, 1848) Milwaukee, Winnebago; not recorded from Wisconsin in Hubricht (1985).

VALLONIIDAE

Vallonia pulchella (Muller, 1774) Milwaukee, Washington, Waukesha, Winnebago.

Vallonia excentrica Sterki, 1893 Milwaukee, Washington.

Vallonia costata (Muller, 1774) Milwaukee, Ozaukee, Washington, Waukesha.

PUPILLIDAE

Gastrocopta armifera (Say, 1821) Milwaukee.

Gastrocopta contracta (Say, 1822) Milwaukee, Ozaukee, Waupaca.

Gastrocopta holzingeri (Sterki, 1889) Ozaukee.

Gastrocopta pentodon (Say, 1821) Kenosha, Milwaukee, Ozaukee, Waupaca.

Gastrocopta tappaniana (C. B. Adams, 1842) Milwaukee; not recorded from Wisconsin in Hubricht (1985).

Vertigo milium (Gould, 1840) Milwaukee, Ozaukee.

Vertigo ovata Say, 1822 Milwaukee.

Vertigo ventricosa (Morse, 1865) Milwaukee; not recorded from Wisconsin in Hubricht (1985).

Vertigo tridentata Wolf, 1870 Milwaukee; not recorded from Wisconsin in Hubricht (1985).

Vertigo gouldi (A. Binney, 1843) Milwau-

kee, Washington; not recorded from Wisconsin in Hubricht (1985).
Columella simplex (Gould, 1841) Adams, Milwaukee, Ozaukee.

STROBILOPSIDAE

Strobilops labyrinthica (Say, 1817) Adams, Fond du Lac, Milwaukee, Ozaukee, Sheboygan.
Strobilops affinis Pilsbry, 1893 Milwaukee.

SUCCINEIDAE

Oxyloma retusa (I. Lea, 1834) Door, Kenosha, Milwaukee, Washington, "Lake Winnebago."
Succinea ovalis Say 1817 Door, Ozaukee, Sauk, Vilas.
Catinella avara (Say, 1824) Milwaukee.

DISCIDAE

Anguispira alternata (Say, 1816) Dodge, Kenosha, Milwaukee, Washington.
Discus cronkhitei (Newcomb, 1865) Milwaukee.
Discus catskillensis (Pilsbry, 1898) Kenosha, Manitowoc, Waukesha.
Discus patulus (Deshayes, 1830) Milwaukee.

HELICODISCIDAE

Helicodiscus shimeki Hubricht, 1962 Milwaukee, Ozaukee.
Helicodiscus parallelus (Say, 1817) Columbia, Juneau, Kenosha, Milwaukee, Ozaukee, Walworth.
Helicodiscus singleyanus (Pilsbry, 1890) Columbia; not recorded from Wisconsin in Hubricht (1985).
Helicodiscus inermis H. B. Baker, 1929 Ozaukee.

PUNCTIDAE

Punctum minutissimum (I. Lea, 1841) Adams, Iowa, Juneau, Kenosha, Lafayette, Milwaukee, Ozaukee, Waupaca; not recorded from Wisconsin in Hubricht (1985).

LIMACIDAE

Deroceras laeve (Muller, 1774) Ozaukee; not recorded from Wisconsin in Hubricht (1985).

ZONITIDAE

Nesovitrea electrina (Gould, 1841) Milwaukee.
Nesovitrea binneyana (Morse, 1864) Adams, Kenosha, Vernon.
Glyphyalinia indentata (Authors) Kenosha, Milwaukee, Ozaukee, Walworth; not recorded from Wisconsin in Hubricht (1985).
Hawaiia minuscula (A. Binney, 1840) Milwaukee, Ozaukee.
Zonitoides nitidus (Muller, 1774) Racine, Waukesha.
Zonitoides arboreus (Say, 1816) Dane, Juneau, Kenosha, Marquette, Walworth, Waushara.
Striatura milium (Morse, 1859) Walworth.

VITRINIDAE

Vitrina limpida Gould, 1850 Milwaukee, Waukesha; not recorded from Wisconsin in Hubricht (1985).

HELICARIONIDAE

Euconulus fulvus (Muller, 1774) Marquette, Ozaukee, Waupaca.
Guppya sterkii (Dall, 1888) Ozaukee; not recorded from Wisconsin in Hubricht (1985).

POLYGYRIDAE

Stenotrema leai leai (A. Binney, 1842) Milwaukee.

Stenotrema fraternum fraternum (Say, 1824) Burnett, Milwaukee, Waukesha.

Mesodon pennsylvanicus (Green, 1827) Milwaukee, Oconto; not recorded from Wisconsin in Hubricht (1985).

Mesodon thyroidus (Say, 1816) Milwaukee, Ozaukee, Waukesha.

Triodopsis vulgata Pilsbry, 1940 Waukesha; not recorded from Wisconsin in Hubricht (1985).

Triodopsis tridentata (Say, 1816) Waukesha; not recorded from Wisconsin in Hubricht (1985).

Triodopsis albolabris (Say, 1816) Burnett, Milwaukee, Ozaukee, Vilas, Waukesha.

Triodopsis multilineata (Say, 1821) Calumet.

Allogona profunda (Say, 1821) Calumet, Kenosha, Waukesha.

Reference Cited

Hubricht, L. 1985. The distributions of the native land mollusks of the eastern United States. Fieldiana Zoology New Series 24:iii-vii, 1-191.

THE UNUSUAL AND THE EERIE IN AARON BOHROD'S EARLY PAINTINGS: 1933-1939

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American Art of the 20th Century exhibits a wide diversity of movements and individual styles, recalled S. R. Koehler's remarks in 1880. According to Koehler, "In periods of transition, in which some men adhere to old faiths, and others tear themselves away from them . . . individualism asserts itself . . ."[1]

The widely divergent styles of the Depression Era in the United States, in which various forms of realism, impressionism, expressionism, abstract, mystical and visionary art flourished are still with us today, as John I. H. Baur predicted in 1951 in his *Revolution and Traditions in Modern American Art.* Indeed as Baur cites the view of René d'Harnoncourt, diversity and change have become permanent characteristics of our art, and it would be the "brave critic who would dare predict what the future balance between [the various] . . . modes of painting will be."[2]

Given the range of "isms" available to artists in the Depression Era, it is often hard to place individuals in one "school" or another. This is particularly true of the work of those young artists who were just beginning their artistic careers during this volatile period.

One such artist is Aaron Bohrod, who, through his lifetime, has been variously labeled as a "painter of the American Scene," a "Regionalist," a "Social Realist," a "quasi-expressionist, half-impressionist," a "surrealist realist," and, finally, a "magic realist."[3]

All of the "isms" undoubtedly could have been applied to Bohrod's art at one time or another in the early years of his artistic career. Like many artists at that time, he experimented with the range of styles available in the Depression Era. The truth is, as Margaret Fish stated, "[Bohrod] has never been anything but a realist,"[4] meaning that he has always been an exponent of representational art of one variety or another.

There is, however, something "unusual and eerie" in Bohrod's early work. It is this "unusual and eerie" element which manifests itself completely in the mature work from 1953 to the present, but that appeared only in budding form in his early works.

My interest in Bohrod's work created a curiosity to investigate the roots of his current style of still lifes of finely-detailed, tightly composed, ironic and whimsical arrangements of mundane and art historical objects painted in a trompe l'oeil technique.[5] This interest in the "unusual" in mundane reality seemed to me to be at the very core of Bohrod's current work.

The transition to this style was, in itself, unusual, in that the majority of artists working around Bohrod in the Depression Era moved from the representational to the more abstract or from the more tightly controlled to the more spontaneous. Bohrod's development was just the opposite. His early representational style is marked by a technique of painting that shows a degree of spontaneity and simplicity, which, over the years, has become progressively more structured through a strict control of painting technique, subject matter and form.[6]

Several critics and art historians have noted this development, referring to "glimmerings," and "certain intimations" and a "developing flair for detailed and precise rendering of subject matter," as well as for an "instinct for finding an unusual angle

[from the] . . . worn and common place . . ." all visible in his early paintings of the 1930's.[7]

None of the critics or art historians, however, have looked closely at his early works for the specific element already present which presaged the development of his later work. In this paper I will show that "the unusual and the eerie," was, in fact, present in his early work.

I will examine the unusual and eerie aspect of Bohrod's work which, I believe, stems from his continual use and subtle underlying emphasis upon the impermanence of the material world. Bohrod's view is delineated by his repeated juxtapositions of objects of mundane reality generally recognized as symbolic of decay and age with those that are symbolic of youth, or material strength and stability.

In this context, unusual and eerie are terms which I shall use to describe and define the unsettling effect this juxtaposition has upon the viewer looking at the material world Bohrod presents in the act of "dematerializing."

Bohrod achieves this effect through the use of several techniques, such as positioning material objects at odd angles, painting in strange colors, exploiting light effects to dramatize and distort reality, painting bleak Midwest winter, night and storm scenes, presenting figures that have enigmatic facial expressions or are turned away or hidden from the viewer, and finally, by painting supposedly solid objects and architecture as disjointed pieces of representational visual information.

It is clear that, in order to make a definitive statement of this view, it would be necessary to see and study Bohrod's early works in good color reproductions. However, these materials are not presently available. Further investigation and research is needed to locate such materials. Therefore, this paper is a "work in progress," rather than a final statement of the view here proposed.

At this point, it will be useful to provide some personal biographical background on Bohrod's early life and artistic training in order to understand the roots of Bohrod's view and techniques.[8]

Aaron Bohrod was born in Chicago in 1907. He started to draw at the age of three or four, copying the comics from daily newspapers. By 12, he was attending art classes in the art school located on the bottom floor of the Art Institute of Chicago. In high school he became the staff artist for his high school magazine and in 1917-1918 he designed several posters for the World War I Liberty Bond and War Saving Stamps campaigns.

Bohrod describes his childhood family financial condition as "poor but not miserably poor." His Russian-born father bought a small grocery store in the predominantly Jewish neighborhood of the old "West Side" in Chicago to provide financial stability for his family. Aaron, aside from being a stock and delivery boy, took delight in presenting, each week, a different imaginative arrangement of grocery wares in the store's display window. He took pleasure in "watching the reaction of casual passersby" to his "first still-life arrangements" of oatmeal boxes and soup cans stacked in strange order.

This interest in the arrangement of mundane material objects and a strong need for financial stability in a time of depression, I believe, underlies Bohrod's long and consistent history as a representational artist trying to please a large, public audience as well as to satisfy his desire to communicate with them as an artist. Later acquired skills, and jobs in the commercial world, continued Bohrod's link with the representational world.

As a teenager, Bohrod attended Crane Technical High School and Junior College where he learned mechanical drawing. This skill he later used to support himself while he continued his art studies. In 1926, while at the Chicago Art Institute, Bohrod ". . . acquired everything in aesthetic education but

real painting experience." In the summer of 1927, Bohrod took a job as a commercial artist for a printing house, designing book jackets and maps, quitting this job to return to his studies at the Chicago Art Institute on a scholarship.

This see-saw between commercial art jobs and fine art studies and productions continued throughout Bohrod's lifetime; indeed, it underscores Bohrod's concern with communicating with the public-at-large. Bohrod had other experiences in the world of fine art and commercial art which also led to his development of a visual "editorial" style, one in which he could make a social comment using art as his vehicle of communication.

From 1929 to 1932, with the nation in financial turmoil, Bohrod took his savings and went to New York where he spent "two . . . fragmented years" at the Art Students' League. Forced to return to Chicago to earn more funds to support his studies at the League, Bohrod took a job as Art Director of a large department store—more arranging and display of wares. He returned to the League in New York in 1931.

It was at the Art Students' League that Bohrod worked with several well-known artists of the time, including Boardman Robinson, John Sloan, Kenneth Hayes Miller, Charles Locke, Richard Lahey and Eugene Fitsch, all espousing a representational style of art.

By all accounts, it was Sloan, however, who made the deepest and most lasting impression on Bohrod and his work. It was with Sloan that Bohrod began to develop his philosophy of art, his admiration for the "ash can" style, and his interest in portraying "an 'American' art dealing realistically with life," particularly the shabbier side of city life. Bohrod also picked up some of Sloan's reportorial point of view and his insistence on the importance of drawing.

According to Bohrod, "To [Sloan], painting was only drawing with oil color." Sloan had admonished his students to ". . . draw everything you *see* or *imagine* or *dream of,* and draw in every conceivable way and with every conceivable tool." And so, Bohrod recalls, Sloan's students drew ". . . at night, in our rooms, we turned out the lights and drew strange things without being able to see our paper. We drew from memory. We drew with the left hand. We drew with both hands at once. We pretended we were Renoir and drew like him. Like Picasso. Like Matisse . . ."

Bohrod admired Sloan's "aesthetic energy, his . . . build-up of form, his ability to capture the flavor of everyday life." The closest Bohrod ". . . ever got to artists of the Stieglitz group was going up in the elevator of that building once with Georgia O'Keefe. They were all much older . . . and had aloof and elitist approaches to painting with which I wasn't comfortable." But he was aware of their work, being an inveterate gallery-goer.

Bohrod, under Sloan's influence and given his personal background and make-up and his several successful commercial art endeavors, felt ". . . more at home with the art that seemed to have something to say to the public."

Bohrod contends that he was attempting ". . . a sympathetic portrayal of commonplace life . . . taking [his] place beside the ordinary American . . . discussing his environment with a silent plea for understanding."

During his years at the Art Students' League, Bohrod was a prodigious learner. As Bohrod recalls, he got off to a bad start with Sloan, overwhelming him "with the task of criticism by volume," and a display of his commercial "slick wrist" in his classroom studies. However, Sloan eventually became supportive of Bohrod's work.

In 1930, while in Chicago working to raise funds to return to the League in New York, Bohrod entered the first of the Depression-inspired outdoor exhibitions held in Grant Park, outside the Chicago Art Institute. This was the beginning of a long career of exhibiting there. At this time, he began several life-

long and influential friendships with fellow artists, Ivan and Malvin Albright, Francis Chapin, Edgar Britton, Constatine Pougialis and William Schwartz.

In 1933, back from New York permanently, Bohrod and his wife took up residence in a kind of artist's colony on North Avenue in Chicago where each artist-family occupied a single studio space, meeting often in sketch groups.

It was also in 1933 that Bohrod won the first of many awards he would receive from the Chicago Art Institute and other museums around the country. Shortly afterwards, several curators visited Bohrod's studio, among them Robert Harshe, Director of the Chicago Art Institute, and Mrs. Juliana Force, Director of the Whitney Museum in New York. Between them, they bought several of Bohrod's works for their museums and selected others for exhibition. Bohrod's career as an artist was officially "launched."

Between 1936 and 1939, Bohrod won three commissions from the Section of Fine Arts, Public Buildings Administration of the Federal Works Agency (FWAP) to paint murals in the Illinois post offices at Vandalia (1936), Galesburg (1938), and Clinton (1939). He also received some financial support through his participation in WPA art projects from 1936 to 1938.

Bohrod won the first of two Guggenheim Fellowships in 1936 receiving recommendations for the grant from fellow artists at the Rehn Gallery in New York who had expressed admiration for his work, Edward Hopper, Reginald Marsh, Eugene Speicher and Alexander Brook. Using the Guggenheim funds, Bohrod chose to tour the United States from 1936 to 1938 rather than go to Europe, as stated in his application.

Aside from the financial rewards, the recognition, and the public acceptance it brought, Bohrod says he valued his entry into the Associated American Artists Gallery in 1939 because it provided him with the "opportunity to meet and work with artists [he] had long admired," including Raphael Soyer, George Grosz, Thomas Hart Benton, John Steuart Curry, Grant Wood and Joe Jones.

Bohrod, as stated earlier, "was interested in viewing [all the] manifestations [in the art of the '30's]." He even deliberately experimented with Cubism and Fauvism in particular, but his ". . . experimentation was quickly exhausted in the discovery for [him] that these were mannerisms unsuited to an artist who would lean on the visual world . . ."[9]

In Bohrod's opinion, although he admired Thomas Hart Benton "for the originality of his vision and for his application of a kind of baroque old-master layering on contemporary life," he also found him "grandeloquent" and "a little frightening," and chose not to follow his "powerful (but rather obvious) rhythms."[10]

Bohrod states that John Sloan's approach to ordinary settings instigated his early desire to "[look] at Chicago in the way Sloan looked at New York and Philadelphia."[11]

Sloan's view then, was the springboard for Bohrod's work of the '30's. However, as Bohrod has said himself, "In the early years, diverse periods of painting come thick and fast for the artist . . . he is never certain for long that he is on the right road, that what he is doing is what he wants to be doing for all time. The struggle for individual style is the great bugaboo of the art student and the young professional. Only when he ceases the self-conscious search for style and loses himself in subject matter that grips him does his painting style emerge." Bohrod's "concentrated and thoughtful arrangement of visual material [and] precise decision of response required for them provided the foundation on which his present work in still life rests . . ."[12]

Bohrod's experimentation with a diversity of styles while he was a student at the Art Students' League is exemplified in several of his works from 1930 to 1933. In *Greenwich Village Gas Station,* an opaque tempera,

1930, Bohrod has attempted to reduce a New York city scape to Cubist flat planes, somewhat reminiscent of Stuart Davis' early handling of similar subject matter in his abstractions of that time. In *Street Corner,* an oil painting done at the same time as the Greenwich Village scene, Bohrod worked in the manner of the "ash can" school and his mentor, John Sloan, delineating a specific city scene, employing a tighter, but still somewhat spontaneous brush stroke, with the emphasis on a closer, pictorial reality favored by Bohrod's teachers at the League. *Clifton Park "El" Platform,* a gouache, also from 1930, lies somewhere between the Greenwich Village scene and *Street Corner* in terms of the brush work employed. Bohrod appears to be experimenting here with Fauvist technique employed to delineate the "ash can" subject matter of a specific city scene. The 1933 *Abstraction,* represents Bohrod's only painting done in a totally non-representational manner and encompasses several modes of abstraction from Synchromy to a Kandinsky-like abstract expressionism to Cubism and Futurism. *Head,* in Tempera and ink, from 1932, resembles the figurative handling and painting techniques employed by the Expressionists, such as Emil Nolde and Georges Rouault; whereas, *North Avenue Beach,* a gouache from 1933 is a combination of impressionist and expressionist techniques.

Turning from these early, student experiments in a variety of styles, we can now consider four works by Bohrod from the year 1939, when, at the age of 32, he was a well-established young artist.[13]

The four works under consideration, the Clinton, Illinois Post Office Mural, *Clinton in Winter, Under the El* (mixed media), *La Salle Street at Night* (oil on gesso panel), and *Maxwell Street, Chicago* (oil on gesso panel), represent works which we will examine to discover "the unusual and the eerie" element which was the forerunner of Bohrod's paradoxically familiar and perplexingly strange and unusual still-life pictorial situations.[14]

Clinton in Winter is a mural painting over the Postmaster's door in Clinton, Illinois. The subject, as described in the FWAP bulletin, is "a readily recognizable scene in the town of Clinton. We see a section of the County Courthouse, the statue of Lincoln, and some of the business buildings around the town square. The figures in the foreground represent types of the town, such as the town merchant, and the farmer from the neighboring country."[15]

The style and technique exemplified in this mural appear typical of those selected throughout the program, one "in which the artist's opinion is subordinated to that of the patron, and the goal is the production of high-quality art objects . . . patterned on the traditional system of private patronage," which, in this case represented the tastes of George Biddle and Edward Bruce and their preference for works in the style of (among others) Thomas Hart Benton, Reginald Marsh, Boardman Robinson, Maurice Stern —and themselves.[16]

Looking closely at the mural, *Clinton in Winter,* we can discover several elements that appear unusual for a FWAP mural. True, this is a scene of the town square and some local types as described in the FWAP bulletin, however, if we examine the mural in detail, we can note some unusual elements.

Starting with the less obvious, let us look at the background. In itself, it gives us a "stage-set" feeling, as if it is a painted backdrop for the large, "real" figures in the central foreground of "the stage" painting.

The scene is winter, the trees are denuded and twisted, dead limbs stretch up behind the central figures and are silhouetted against a darkening sky that suggests an approaching storm coming in from the left of the mural. One street light stands in front of the group of trees, and another on the other side of the central square—far back and on

the left of the lower mid-plane of the picture—not much light to illuminate this large area in the approaching storm.

The horizon point of the mural is quite low—suggestive of the flat, Midwest landscape. The business buildings and shops, which stretch across this horizon point from the left to just beyond the right center, are squat, dull and drab. We glimpse a church faintly through a break between the business district buildings to the left and center and the ponderously large, old County Courthouse which looms up across almost the entire right one fourth of the mural. One wonders if a visual editorial comment is being made here that between the dominance of a cold and aloof "state" (as represented by the Old Courthouse) and the importance of "Business" (as represented by the row of shops and office buildings) the supposedly comforting institution of the "Church" is somehow forced into a hazy background.

The statue of Lincoln is seen in profile, its back to the Courthouse, and, although centrally placed in the mural, the figure of Lincoln is just a statue and does not "see" the plight on the faces of the group of people in the central foreground, two of whom look directly at us.

In looking at a detail of this group we see, on the left, a woman with her hand held to her head—perhaps against the cold and wind, or as symbolic of anguish. Although wearing a nice warm fur-collared coat, her eyes are closed and the expression on her face is hard to fathom. The facial expression, combined with the hand gesture of her right hand and the obvious tugging motion of her left arm to pull her child to her, all add to an enigmatic impression of the mother-child relationship, an expression of grief, or anxiety, or some type of tension between the two and us, the viewers.

To the right of these two figures, we see the face of a very small young boy. One can only describe the expression here as wan and sad, at the least. The four remaining figures on the right side of the group are adults. Of these, the left side figure appears to be a postman, judging from his official cap—and the location of the mural in the Main Post Office of Clinton. This figure does not look at us—or anybody—just distractedly to the left side of the mural. The woman on the right, with a scarf on her head, and wearing a "fur" collared coat similar to the lady's on the left, is partially hidden from our view, in fact, we do not see her face at all. That leaves the two central male figures. The "businessman" (the glasses and clothing are emblematic of his status) wears a warm overcoat, warm gloves, ear muffs and a stylish hat. He stands behind the "farmer," his eyes downcast, not looking at us, or at the "farmer"; in fact, only the small child and the wizened, worn old "farmer" look directly at us.

There is also a visual editorial comment which Bohrod appears to be making between the "businessman"/"farmer" relationship dependent upon the positioning of the figures, the downcast eyes of the "businessman," the gesture of his right, gloved hand—which is either being raised to further avert his view of the farmer, or, at least, to defend himself in some way.

It is the facial expression and body position of the white-haired "farmer" that carries the major statement of Bohrod's visual editorial about the Depression and age, and is a counterpoint to the facial expression and position of the small boy, who also stares straight at the viewer.

The farmer leans a little to the left—off-balanced—his sagging jacket is open, exposing him to the freezing cold and revealing his worn overalls and a shirt without a tie. On his head he wears what may be either an old army veteran's cap or a railroad conductor's cap. He has something slung over his back which he holds tightly with his left hand. His face is haggard, tired and care-worn, the skin on his neck sags with age, his white mustache droops downward, and his eyes ex-

press an enigmatic emotion—perhaps deep sadness, or, at least—melancholy.

Far from "heroizing" these figures, as stated in a local newspaper at the time,[17] Bohrod has painted a visual editorial comment of not only his view of the Depression, but also of the impermanence and instability of the "real" world and life itself. His figures are, indeed, melancholic, not heroic.

As Park and Markowitz point out in their *Democratic Vistas,* "The town and its inhabitants look drab and grim . . . elements which are ". . . sometimes characteristic of Social Realism, "in direct contrast with the "cheeriness of much American Scene painting. Bohrod's *Clinton in Winter* mural reflects "social Realist criticism . . . portraying ordinary citizens as sad, strange, and even ugly, standing listlessly in dreary places . . . the victims of the Depression, or perhaps of small town life."[18]

What struck Park and Markowitz about this work was also discussed by Linda Nochlin who commented about the "strangeness" of the work—as if there was ". . . something ominous, sinister, willful and . . . alienated—alienating—about [it],"[19] making the work representative not only of the time—the Depression—but of the response of Bohrod to it as an individual.

There are other elements which add to this feeling of "strangeness" besides the melancholy portrayal of the figures, and the drabness of the town—elements that were part of Bohrod's early work which gave them the tone of unusual eeriness. In addition to this treatment of figures and buildings, Bohrod also tended to paint winter, stormy, or night scenes with the resultant mood associated with them. He also often depicted denuded and gnarled trees, large, gloomy Victorian buildings, peeling paper, crumbling and decaying buildings of wood and brick . . . in fact, the decomposition of the material world in his paintings adds to the unusual, eerie and melancholic quality.

In contrast are Bohrod's two earlier Post Office Murals, one at Vandalia, from 1936, *Old State Capitol,* which depicts another town square, this time dominated by a centrally placed view of the old state capitol of Illinois. The scene is in summer-time, and the figures are quite small and insignificant in the bucolic setting, except for one peculiar detail. One of the figures on the lawn is pointing to a window from which, supposedly, Abraham Lincoln leaped when, as a member of the State Legislature, he wished to avoid a quorum when an issue he opposed was being voted upon.[20]

The other mural, in Galesburg, done in 1938, is even more typical of the "heroic" style of portraying American pioneers—a style and subject matter even more sought after by the FWAP.

Some of the eerie and unusual qualities in the Clinton mural are more readily visible in works by other artists of the time whom Bohrod admired, Reginald Marsh, Raphael Soyer and Edward Hopper. In Raphael Soyer's *In the City Park,* 1934, the melancholic treatment of the figures is very similar to that in Bohrod's *Clinton in Winter.* The physical setting is also similar—a park with a statue that resembles Bohrod's Clinton town square setting. The suffering, Depression Era figures are also in the forefront of the painting, their expressive faces the focal point of the painting, as are the figures in the Bohrod work.

In *Under the El,* mixed media-gouache and crayons, the ominous atmosphere present in the small town during the Depression is depicted in this scene under the trestle of the Chicago elevated train. Our progress into the picture is immediately halted by an orange fence-like material resembling barbed wire. The abstract lines and patterns of the elevated trestle at the top of the picture are repeated in the shadows below, where we see a slumped-over figure of a man, his head hanging down, his arms clutching his knees, resting against one of the powerful girders of the "El." Just behind and above this figure and girder, we

see the face of a young girl on a peeling advertisement on a red brick wall. On the telephone pole to the left of the girl's face hangs another smaller, torn poster. In the middle ground, center portion of the picture we see a few low-lying old buildings with weeds growing around them. We do not know if these are houses or warehouses. Even though the horizon point is low, the view of the sky is cut into narrow, vertical bands by the vertical girders of the "El" and the telephone pole. What we do see of the sky is a storm, advancing from the left of the picture to the right. The left half of the sky in the picture is gray, the right half, blue, cut in the middle by the curving sweep of the "El" from the upper foreground to the mid-background. The color in the picture seems incidental to the draughtsmanship, the emphasis being on the lines of the "El" girders, the buildings, the wire fence in the lower foreground, and the lone figure sitting on the ground beneath the "El."

There are two statements being made in this picture, consistent with Bohrod's point of view regarding the Depression, specifically, and Life, in general. Unlike the Precisionists, Bohrod's depiction of the "El" is not a positive symbol of the industrial power of America (like various artists' scenes of the Brooklyn Bridge or Sheeler's factories and granaries). The "El," the fence in front, the buildings around the figure—almost lost under the shadow of this structure, creates a prison-like atmosphere. At the very least, the figure appears small, depressed and insignificant compared to the city structures that loom around him. This is underscored by the incoming storm, since we can see that the "El" trestle is full of holes and will afford little protection for the man.

The second statement Bohrod makes is more subtle here, but directly present in his work from the '50's onward—the contrast of "age and decay"—the man under the "El" and "youth"—the artificial face on the advertisement, repeated by the contrast of the decay of the buildings, the poster and ad and the seeming stability and strength of the "El."

This interest in the contrast of the "seeming stability" of city and industrial structure (Society) and the decay through age and wear (Time) is visible in earlier and later works of Bohrod as well as in works of his contemporaries. It is at this point that we can begin to see in Bohrod's art the budding emergence of interest in "surreal" or "fantastic" effects based on everyday existence and used, as in the early works of Guglielmi and Edward Hopper, among others, as a social or personal commentary heightened by the use of these strange "surreal" touches.

This "fantastic" or "strange" view can be seen again in Bohrod's 1939 gouache, *Ogden Avenue Viaduct,* for which *Under the El* may have been a preliminary work. The whirling clouds, the curve of the viaduct and the curving stairway create an eerie "eye of the hurricane" effect. While the curving stairway does go to the top of the viaduct, it has the odd effect of going nowhere. Below the viaduct, a lone figure sits huddled against one of the supports, just as in *Under the El,* and on the right side of the work we see several shabby apartment buildings and houses. Here also, the viaduct is not seen as a heroic product of industrialization, and the figures in the picture are isolated from one another.

In an earlier city scene, *Clark Street, Chicago,* 1934, we see this emergent contrast of stability and decay. Looking at the seemingly solid brick buildings, one can see the wear and tear on wooden window sashes, awnings, foundation bricks and signs—shown here in careful detail. Even more evident, the entire street in front of these "solid establishments" is being torn up to get at the "rotten foundations" or "faulty underpinnings." The artist has even placed an "observer" of this event in a centrally located window above the workers. We meet this meticulous handling of material details and this concern with the transient and im-

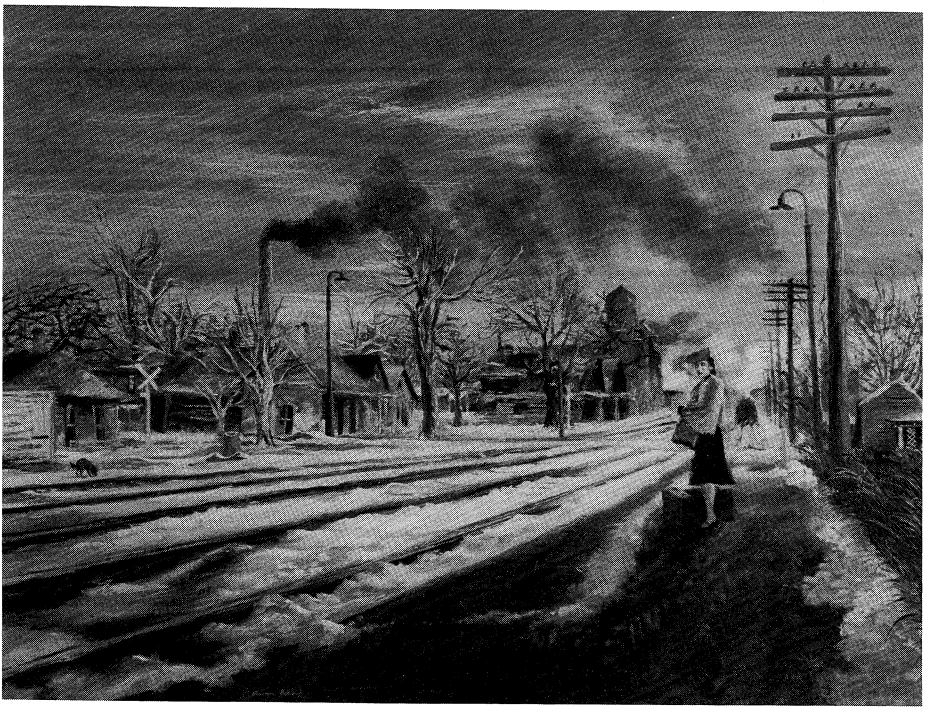

Fig. 1 Waiting for the 3:30. Oil on gesso panel.

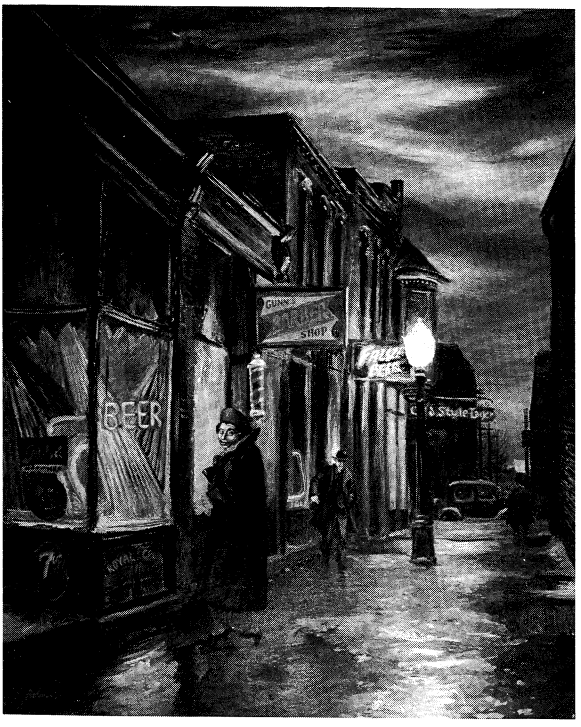

Fig. 2 Neon Nocturne. Oil on gesso panel, 20 × 16″, ca. 1940.

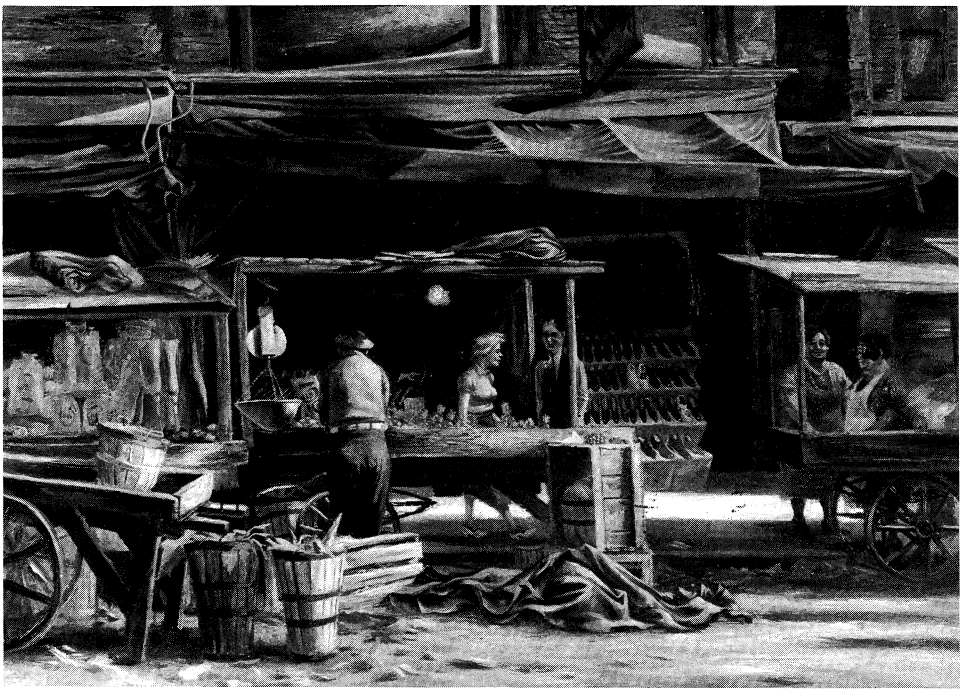

Fig. 3 Maxwell Street market. Oil, 1939.

Fig. 4 Reflections on a shop Window. Oil on gesso panel, 36 × 28½″, ca. 1941.

permanent nature of life again and again in Bohrod's mature works.

Charles Burchfield's *Black Iron* watercolor painting appeared in the 1940 International Exhibition of Watercolors in the Chicago Art Institute about the same time as Bohrod's *Under the El* was done. A Peter Blume study for Eternal City appeared in that same show, in which Bohrod was also exhibiting. Numerous works by Burchfield, several by Blume, and several by George Biddle, including *Under the Elevated* had appeared in the annual International Watercolor shows at the Chicago Art Institute from the beginning of Bohrod's exhibition in that show since 1931.[21]

In Burchfield's *Black Iron,* 1935, we see a view of a ponderous metal structure that has been viewed as Burchfield's "grim indictment of industrial waste, the power of a technological society to create an inhuman desert."[22] At the very least, it is not a view of industrialization as heroic, in this, both Burchfield and Bohrod concurred.

Bohrod's *Waiting for the 3:30,* (in the Truman Library) an oil on gesso panel painted around the same time as the *Under the El,* combines several of the elements discussed previously that create an unusual and eerie atmosphere: a winter scene, decaying old buildings along railroad tracks, denuded, gnarled winter trees, and here we see industrial smoke blowing across the scene, adding another element to the social commentary. In this painting, the contrast of the decay and impermanence of "the wrong side of the tracks" is with the stylishly dressed young woman who looks at us as she clutches her bag and stands alone and unprotected in the cold.

By the end of the '30's, Bohrod's work had certain elements in it that could be called "unusual and eerie." These elements he used to convey a social comment about life in the Depression and Life in general, with particular regard for showing the contrast between age, decay and transiency with youth and the seeming solidity of the "real" world.

This eerie contrast was heightened in a series of paintings begun in the late '30's, of which *La Salle at Night* is an example. The street scene here is again old and run down, shabby. The neon light from the sign "Eat" casts a weird glow over the entire painting, picking out figures, architectural details, reflections on the damp, cobbled street. This eerie neon glow is repeated by the moon glow in the sky behind the central buildings. One is reminded of Ryder, except here we see a scene of a mundane street on the near northside in Chicago. The buildings are "tumble-down" and lean at odd angles to one another and the street, which itself runs at an angle across the picture plane; their windows are also somewhat askew, particularly in the house on the right behind the partial, oddly disengaged picket fence. In fact, everything, including the car in front of the building, seems "slightly askew." One also wonders about the character of the young lady walking towards us, arms akimbo, her dress clinging to her body, a faint smile on her face. Edward Alden Jewell described Bohrod's brushwork in these "Neon Light" street scenes as ". . . at once vivid and subtle . . . luscious, alive with texture . . ."[23] To Bohrod, "These neon nocturnes, with streets and people bathed in pink and green glow [were filled] with the strange light sometimes reflected on wet pavement" were fascinating for several years.[24]

This interest in "strange" light effects and the "weird" quality they produced can also be seen in many of Edward Hopper's night scenes which may have been the inspiration for the enigmatic mood in Bohrod's paintings. Bohrod's *Neon Nocturne* from around 1940 and *Oakdale Avenue at Night,* also around 1940 reiterate this strange luminescence of neon and moonlight, eerie reflections in shop windows, strange, often alone, female figures; shabby or old, ramshackle stores or Victorian homes; cloudy, mysterious skies; twisted, dead trees, and shop signs—neon and otherwise. Some paintings, like *La Salle Street* are close to Hopper's

eerie night cityscapes, others, like *Oakdale Avenue,* recall paintings by Charles Burchfield, like *Promenade,* "infused . . . with melancholy fantasy."[25]

The odd, eerie "off-color" neon light coloration and enigmatically smiling women staring at the viewer are also suggestive of Toulouse Lautrec's and later expressionist paintings of the bistros and environs of various red light districts.

This eerie element and interest in the transiency of material reality continues to develop in Bohrod's work of the late '30's and after World War II, but turns from city and landscape scenes back to the origins—Bohrod's still-life arrangements—the shop window in his father's grocery store.

During the '30's, Bohrod painted numerous shop scenes, such as *Maxwell Street, Chicago,* without realizing the symbolic quality of the objects he painted. He only recalls being fascinated by the "jumbled bric-a-brac" and "vaguely [suggestive] . . . junky objects," and the interesting light effects and reflections in the glass window panes of antique shops.[26]

Maxwell Street, Chicago, an oil painting on gesso panel, is a close-up view of the pushcarts and small shops of this well-known wholesale market street on the old West side of Chicago. We are standing in the street looking at one section of shops and pushcarts. On the street we see the refuse and crates of produce of two grocery pushcarts in the middle and left side of the painting. The figure of the grocer has his back towards us, but it is a self-portrait of Bohrod, the grocer's son, nevertheless, in one of the first of many whimsical inclusions of himself that appear regularly in his later still-life arrangements.[27] To the left of the produce scale, in the second grocery cart are arrangements of sacks of flour, brooms and potatoes. The contents and structures of both carts are fairly detailed, as is the rendering of the dry goods shop directly behind the center cart, with its racks of men's suits and rows of sometimes matched, and sometimes whimsically mismatched, shoes. The "proprietor" of the dry goods shop stands, hands in pocket, cigar in mouth, eying an approaching young woman, perhaps a prospective customer. To the right, two heavy-set pushcart owners (they have aprons on), stand by their pushcart, which appears empty. The upper half of the painting is an intricate composition of the geometric shapes of the awnings and curtains above and on the sides of the shops, the windows above the shops, and the brick work and signs of the buildings in which the shops are located. The upper section is handled in a broader fashion than the market areas below, although the overall brush technique is not tightly detailed. Bohrod's color here seems incidental to the drawing—a Sloan-type painting . . . a lively drawing with oil color.

What is of particular interest in this painting is the detailed treatment of the material objects: the produce, baskets, produce scale, the awnings and side draperies and the reflections in the large window above the central pushcart.

We can see this interest in the texture and appearance of objects in the earlier *Landscape Near Chicago*, an oil painted in 1934 and purchased by the Whitney Museum. The detail with which materials and objects are rendered stands in a direct line to Bohrod's later trompe l'oeil technique, particularly in the rendering of the junk objects in the lower left corner of the painting, the two central jalopies and the strange materials of the somewhat odd, unreal "house," which has the appearance of being an old piece of junk, itself.

Bohrod's interest in shops and shop windows can be seen again in the 1939 gouache, *South State Street, Chicago,* in which the central subject is a watch and jewelry store and everything, including signs, buildings and people seem to be arranged around this display of wares.

Coming closer to the fascination with objects and their use as symbols is the '39 oil

painting, *Still Life with Ferdinand,* painted as a deliberate grouping of Bohrod's eldest son's favorite toys.[28] They stand on an up-tilted table, an angle at which they should all slide off, and they are rendered with broad brush strokes—no attempt is made to fool the eye. however, the table they are "attached" to stands just in front of an empty frame—an allusion to the unreality of the reality of painting, and to the right, we see a "real" Bohrod framed and ready for shipping resting against a wall, the paradoxically familiar and perplexing pictorial situation which Futtner mentioned in his Arts Magazine article of May, 1985.

In Reflections on a Shop Window, an oil on gesso painted ca. 1941 and *Antiques,* oil on gesso, painted ca. 1947, we have the forerunners of the objects Bohrod was to use in his later still-life arrangements—the odd, jumbled bric-a-brac physical momentos of life associated, in each of these paintings, with the process of the physical aging of people (the old ladies in both paintings), the transiency and passing of time for the physical world (the reflections of clouds, buildings—the impermanent permanent structures around us), all suggestive in Bohrod's later work of the "elusive beauty" he sought to report as an artist.[29]

In his own writings and in those of his most recent critics, Bohrod acknowledges the influences of not only John Sloan, and the Regionalists, but also of the work of his good friend, Ivan Albright, as well as recognizing the influence on his later work of the 19th Century American realists Peto and Harnett, and, more recently, on an inclusion of a surrealist or fantastic element in his work.[30]

In our review of Bohrod's early work, we have seen that his posing of pictorial situations which are at once paradoxically familiar and perplexingly strange has been part of Bohrod's work since he began arranging oatmeal boxes and soup cans in a strange order to watch the reaction of casual passersby.

Notes

[1] S. R. Koehler, "The Future of Art," American Art Review, 1:32 (1880); as cited in John I. H. Baur, *Revolution and Tradition in Modern American Art,* Harvard University Press, Cambridge, Massachusetts, 1951, p. 146.

[2] John I. H. Baur, *Revolution and Tradition in Modern American Art,* op. cit., pp. 145-146.

[3] Bohrod "labels" appear in various publications, the following list is a sampling of these appearances:

a) "painter of the American Scene": in John I. H. Baur, op. cit., p. 19.; also see Barbara Rose, *American Art Since 1900,* Praeger Publishers, New York, 1975, p. 97.

b) "Regionalist": Barbara Rose, op. cit., p. 97., also see "John Steuart Curry, Aaron Bohrod, John Wilde: Leaders in Wisconsin Art 1936-1981, "Milwaukee Art Museum, 1982, catalog, p. 25; also in "Bohrod TV gala," by James Auer, Journal Art Critic for *The Milwaukee Journal,* November, 1982 (personal clipping from Aaron Bohrod).

c) "Social Realist": "Aaron Bohrod: Still Life in the Old Boy," television program for WHA-TV, Madison, Wisconsin, November 16, 1982, written and directed by Steven Jandacek; also see Marlene Park and Gerald E. Markowitz, *Democratic Vistas,* Temple University Press, Philadelphia, 1984, p. 162.

d) "quasi-expressionist, half-impressionist": Clement Greenberg, "A Review of a Ben Shahn Exhibition," *The Nation,* 1 November 1947, pp. 431-482.

e) "magic realist": "Aaron Bohrod: Still Life in the Old Boy," WHA-TV program, op. cit.; James Auer, "Bohrod TV gala," op. cit.; "Aaron Bohrod," by Joseph L. Futtner, *Arts Magazine,* May, 1985, p. 8; John Lloyd Taylor, "Aaron Bohrod: A Retrospective Exhibition 1929-1966," Catalog, Madison Art Center, Madison, Wisconsin, 1966.

f) "surrealist realist": Joseph L. Futtner, *Arts Magazine,* op. cit., p. 8.

[4] Margaret Fish Rahill, curator, Charles Allis Art Museum, catalog, "Aaron Bohrod: Recent Paintings, July 15-August 31, 1984," funded by the Wisconsin Humanities Committee, n.p. (Tha author is also the art critic for *The Milwaukee Sentinel*).

[5] John Lloyd Taylor, Director, Madison Art Center, catalog, op. cit.; Margaret Fish Rahill, catalog, op. cit.; Joseph L. Futtner, op. cit., p. 8.; see also the illustrations in Aaron Bohrod, *Aaron Bohrod: A Decade of Still Life,* The University of Wisconsin Press, Madison, Milwaukee and London, 1966, pp. 59-298.

[6] John Lloyd Taylor, catalog, op. cit.; Joseph L. Futtner, op. cit., p. 8.

[7] Margaret Fish Rahill, op. cit.; John Lloyd Taylor, op. cit.; Joseph L. Futtner, op. cit.; and Jeanette Lowe, *The Art News* (personal clipping of Aaron Bohrod—undated), n.p.

[8] All of the biographical material and various quotations by and about Bohrod come from the following sources:

a) Personal Correspondence and telephone conversations between Carole Singer and Aaron Bohrod, Oct.-Nov., 1985.
b) "Aaron Bohrod" in *Who's News and Why*, Vol. 16, No. 2, February 1955, The H. W. Wilson Co.: New York.
c) "Aaron Bohrod Papers," Archives of American Art, Smithsonian Institution.
d) "Holger Cahill Papers," Archives of American Art, Smithsonian Institution.
e) *Aaron Bohrod: A Retrospective Exhibition 1929-1966,* catalog, Madison Art Center, Madison, Wisconsin, 1966.
f) *Aaron Bohrod: Recent Paintings,* catalog, Charles Allis Art Museum, Milwaukee, Wisconsin, 1944.
g) Harry Salpeter, "Bohrod: Chicago's Gift to Art," Esquire Magazine, March, 1940 (personal clipping of Aaron Bohrod), pp. 62-63 and 101-102.
h) Aaron Bohrod, *Aaron Bohrod: A Decade of Still Life*, The University of Wisconsin Press, Madison, Milwaukee and London, 1966, pp. 1-25.
i) Patricia L. Raymer, "Aaron Bohrod," The Milwaukee Journal Insight Magazine, November 12, 1972, pp. 18-22.

[9] Aaron Bohrod, in a letter to Carole Singer, November, 1985.

[10] Ibid.

[11] Ibid.; also see Harry Salpeter, op. cit., John Lloyd Taylor, op. cit., Margaret Fish Rahill, op. cit., and Joseph L. Futtner, op. cit.

[12] Aaron Bohrod, *Aaron Bohrod: A Decade of Still Life,* op. cit., p. 13.

[13] See autobiographical material—ftnote. 8.

[14] Joseph L. Futtner, op. cit., p. 8.

[15] FWAP Bulletin, Clinton Illinois Post Office, 1939.

[16] As cited by Edith Tonelli, *Massachusetts Federal Art Project,* Boston University Ph.D. Dissertation, 1981, pp. 24-26.

[17] Personal clipping of local paper from Mrs. Howard Lee Harrell, Clinton, Illinois.

[18] Marlene Park and Gerald E. Markowitz, op. cit., p. 162.

[19] Linda Nochlin, "Return to Order," *Art in America 69* (September, 1981), p. 76.

[20] FWAP Bulletin, Vandalia, Illinois Post Office, 1936.

[21] From Catalogs of shows at the Chicago Art Institute, 1931-1942.

[22] Ian Bennett, *The History of American Painting,* The Hamlyn Publishing Group Limited, London, 1973, p. 188.

[23] Edward Alden Jewell, New York Times review, (personal clipping of Aaron Bohrod).

[24] Aaron Bohrod, op. cit., p. 21.

[25] Suzanne Muchnic, "Welliver," a review in Book Section, *The Los Angeles Times,* Nov. 17, 1985.

[26] Aaron Bohrod, op. cit. p. 23.

[27] See cover and illustrations of Aaron Bohrod, op. cit., p. 102.

[28] Harry Salpeter, op. cit., p. 102.

[29] Aaron Bohrod, op. cit. pp. 23, & 53-55, and also in Letter to Carole Singer, Nov., 1985.

[30] Joseph L. Futtner, Op. cit., p. 8.

HAWTHORNE'S ENOCH: PROPHETIC IRONY IN *THE SCARLET LETTER*

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"A prophet or magician skilled to read the character of flame"[1] must fathom the mystery of *The Scarlet Letter*'s little Pearl, a secret first read by Roger Chillingworth, a practitioner of black arts, whose subtle torture forces the Rev. Mr. Dimmesdale to take up his principal prophetic office: the public admission that the child is his daughter.[2] In confessing to his startled flock that he has put on "the mein of a spirit, mournful because so pure in a sinful world!—and sad, because he missed his heavenly kindred" (p. 255), the minister accurately presents the effect of his anguished hypocrisy upon the congregation: they have seen him as angelic. In his study, Dimmesdale himself had observed in his glass mocking devils and "a group of shining angels, who flew upward heavily, as sorrow-laden, but grew more ethereal as they rose" (p. 145). These unhappy angels provide a significant pattern of dramatic irony for interpreting Dimmesdale's role as prophet in the romance.

During the minister's Election sermon, the community is affected "as if an angel, in his passage to the skies, had shaken his bright wings over the people for an instant,—at once a shadow and a splendor,—and had shed down a shower of golden truths upon them" (p. 249). So impressed are they, that it would not "have seemed a miracle too high to be wrought for one so holy, had he ascended before their eyes, waxing dimmer and brighter, and fading at last into the light of heaven" (p. 252). The people's apparent blurring of the distinction between what were traditionally two separate orders of creation, men and angels, is suggested earlier in the book when the sexton remarks to the minister that the great celestial letter betokens Governor Winthrop's being "made an angel" (p. 158). That Hawthorne may be accurate in presenting popular belief is supported by Puritan tombstone carving—a sample of which provides the book's striking final image—making no distinction between saved souls and angels.[3] The general mind therefore accorded with a long tradition of Neo-Platonic philosophers (Marsilio Ficino, for example), and with Milton, whose Raphael says to Adam, "Your bodies may at last turn all to spirit, / Improv'd by tract of time, and wing'd ascend / Ethereal" (*Paradise Lost,* V, 497-499). It also accorded with literature widely read in Hawthorne's day.[4]

Readers of such works as Edward Young's *Night Thoughts,* which suggested that,

> Angels are men in lighter habit clad,
> High o'er celestial mountains wing'd in flight;
> And men are angels loaded for an hour,
> Who wade this miry vale, and climb with pain,
> And slippery step, the bottom of the steep,[5]

would recognize the plight of Dimmesdale, "the man of ethereal attributes, whose voice the angels might else have listened to and answered," kept from climbing the Puritan patriarchs' "mountain-peaks of faith and sanctity" by a "burden . . . of crime or anguish" (p. 142).

Dimmesdale's identification with angels is given greater ironic force by his prophetic office for the community. While he seems to have attained what the "true saintly fathers" of the Puritan church lacked, "the gift that descended upon the chosen disciples, at Pentecost, in tongues of flame," which enabled them to communicate with "the whole human brotherhood in the heart's native langauge" (pp. 141-143), the minister

is tortured by his hypocrisy. He responds to Hester's assurance that he is reverenced: "Canst thou deem it . . . a consolation, that I must stand in my pulpit, and meet so many eyes turned upward to my face, as if the light of heaven were beaming from it!—must see my flock hungry for the truth, and listening to my words as if a tongue of Pentecost were speaking!—and then look inward, and discern the black reality of what they idolize? (p. 191). Yet as he here presents himself, and as he appears at the Election sermon (XXXII), Dimmesdale does fulfill a prophetic and apostolic role. He may serve, in fact, as a type of Moses (Exod 34:29) or Stephen (Acts 6:15), both of whose countenances are illuminated like those of angels while they discourse on essentially the topic of Dimmesdale's sermon, "the relation between the Deity and the communities of mankind" (p. 249).

As he himself recognizes, the minister's "apostolic" gifts are linked to his passion for Hester and his guilt in hiding his parentage of Pearl. In the forest Dimmesdale, seemingly a failed Puritan prophet, is strengthened by Hester, whom he calls "my better angel"—perhaps in a parody of Kings 19:4—and whose resolution to run away with him makes him feel "made anew, and with new powers to glorify Him that hath been merciful" (pp. 201-202). When he delivers his sermon, he is indeed taken up by "a spirit as of prophecy" which constrains "him to its purpose as mightily as the old prophets of Israel were constrained" (p. 249), but his final revelation is not of God's relationship to men, but of his relationship to his daughter. Throughout *The Scarlet Letter,* the tensions between the minister's earthly emotions and the biblical types through which they are perceived by Dimmesdale himself and by his Puritan congregation are particularly amplified in his role as prophet transformed to angel.

Dimmesdale is supposed to belong naturally among the elders "whose faculties had been elaborated by weary toil among their books, and by patient thought, and etherealized, moreover, by spiritual communications with the better world, into which their purity of life had almost introduced these holy personages, with their garments of mortality still clinging to them" (p. 141). Since, as has been seen, the public view is that Dimmesdale might be miraculously translated to heaven, he may be likened to Elijah, a prophet so removed. But another figure is more explicitly suggested.

The Puritan imagination was enough affected by the matter of prophets lifted to heaven to have included in *The New England Primer,* the substance of which little Pearl is said to have mastered (pp. 111-112), its fifth question, "Who was the first translated?"[6] The answer is Enoch, with whom Dimmesdale contrasts himself in a sermon he dare not deliver: "I, in whose daily life you discern the sanctity of Enoch—I, whose footsteps, as you suppose, leave a gleam along my earthly track, whereby pilgrims that shall come after me may be guided to the regions of the blest,— . . . I . . . am utterly a pollution and a lie" (p. 143). Even Chillingworth makes reference to Enoch in his comment on "saintly men, who walk with God" (p. 122), echoing Genesis 5:24. Enoch, however, is a figure who transcends the bounds of orthodoxy, and to understand him better we must consult "the lore of the Rabbis" (p. 126), which occupies a place in the minister's study.

The pseudepigraphical *Book of Enoch,* based on Genesis 6:1-4, contains the prophet's visions of heaven, including the punishment of the fallen angels. It enjoyed popularity in Europe in several versions, may have influenced Milton, and appears to have been on Pico della Mirandola's reading list; in discussing man's potential to make himself "an angel, and a son of God," Pico writes, "metamorphoses were popular among the Jews. . . . For the more secret Hebrew theology at one time reshapes holy Enoch into an angel of divinity."[7] Romantic thought also inclined toward such metamor-

phoses, and the figure of Enoch naturally attracted its attention, as did those fallen angels with whom he is associated.[8]

New translations of *Enoch* were subjects of critical discussion in Hawthorne's day. In addition to striking chords of Neo-Platonism, they also raised questions about the nature of revelation and focused attention on archetypal readings of the world's religious literature. A compendium of Romantic uses of *Enoch*'s themes is an 1833 review in *Fraser's Magazine,* which discusses literature and inspiration. After quoting Lycidas, it takes up Hawthorne's favorite symbol of revelation, the heart: "Home! sweet home! Look homeward!—there lies 'the crypt, the ark, the chest!' or whatever other 'receptacle' in which inspired writings shall be found. Home! Let each man place his hand on his heart, and find it there. There is the place of mystery, both of godliness and iniquity. Thence must come every revelation worthy of the name."[9] Certainly Dimmesdale's characteristic gesture of putting his hand to his heart indicates his withholding of his inner secret from the community; and after his confession of his pose as a mournful spirit, he does in fact display "what he bears on his own breast, his own red stigma," which "is no more than the type of what has seared his inmost heart!" (p. 255). This final revelation links him to Hester and Pearl, the living embodiment of the scarlet letter.

Pearl's role is parallel to that of Noah in *The Book of Enoch.* Like Noah, she is one of those strange children more suited to be among angels than among men (p. 90). In *Enoch,* Lamech laments, "I have begotten a son, unlike to other children." He worries that, "He is not human; but resembling the off-spring of the angels of heaven, is of a different nature from ours, being altogether unlike us. His eyes are bright as rays of the angels."[10] Hester raises similar questions about Pearl. "What is this being," she asks, "which I have brought into the world!" (p. 96). Though Enoch is able to foretell great things of Noah, however, Dimmesdale can only assure his daughter a human future by admission of his own passion in fathering her.

An admission of passion by the community's "angel" puts him in the company of those angels in *Enoch* who fell for "the daughters of men" (Genesis 6:2). Carl Jung's discussion of Byron's "Heaven and Earth," which treats the union of angelic and human, summarizes well some of the themes Hawthorne develops in the case of Dimmesdale: "The power of God is menaced by the seductions of passion; heaven is threatened with the second fall of angels. If we translate this projection back into the psychological sphere from whence it came, it would mean that the good and rational Power which rules the world with wise laws is threatened by the chaotic, primitive force of passion."[11] Throughout the romance, especially in the forest scene, passion is linked with lawless nature (p. 203). The *via media* of passion and reason is domestic. The home for which each of the characters strives ought to be a means of keeping passion in bounds. Pearl, because she is the embodiment of adulterous passion, in her final domestication signals the resolution of the tension between passion and law.

Unlike Enoch, Dimmesdale can neither translate nor see into the next world. Hester, who seems to hope for some reunion there with the minister, asks him, "Thou lookest far into eternity, with those bright dying eyes! Then tell me what thou seest?" He can only respond with the injunction to trust in God (p. 256). He is an Enoch who ends up in the graveyard, where he shares with Hester the single tombstone indicative of the community's acceptance of their bond in the stigma of the letter; however, this union is also found in the living letter, Pearl. For "their earthly lives and future destinies were conjoined" in Pearl, who is "at once the material union, and the spiritual idea, in whom they met, and were to dwell immortally together" (p. 207). Dimmesdale is

brought to reveal his relationship to the organic world in Pearl, and his prophetic office points to the values of the human heart and the domestic circle.

Notes

[1] Nathaniel Hawthorne, *The Scarlet Letter,* ed. William Charvat, Vol. I. Centenary Edition of the Works of Nathaniel Hawthorne (Columbus: Ohio State University Press, 1962) p. 207. All subsequent references to this volume will appear in the text.

[2] Chillingworth's black arts are treated in my Hawthorne's "Chillingworth: Alchemist and Physiognomist," *TWA,* 72 (1984), 8-16.

[3] Allan I. Ludwig, *Graven Images: New England Stonecarving and It's Symbols* (Middletown: Wesleyan University Press, 1966), p. 216. In addition to the focus on the graveyard in *The Scarlet Letter,* see "Chippings with a Chisel" in *Twice-Told Tales.*

[4] For an analysis of how this distinction disappeared in Ficino, see Michael J. B. Allen, "The Absent Angel in Ficino's Philosophy," *Journal of the History of Ideas,* 36 (1975), 219-40. The backgrounds of Romantic thought show a distinct movement in this direction; angelic transformation is a favorite theme in its occult sources especially. See Auguste Viatte, *Les Sources Occultes du Romantisme* (Paris: H. Champion, 1928).

[5] "The Christian Triumph, Night IV," Vol. I. *The Complete Works,* ed. James Nichols (London, 1854), 534-42, p. 59. *Night Thoughts* originally appeared 1742-1745.

[6] *The New England Primer* (Hartford: Ira Webster, 1843).

[7] *On the Dignity of Man,* trans. Charles Glenn Wallis (Indianapolis: Bobbs-Merrill, 1965), pp. 5-6. For speculation on Milton's contact with *Enoch,* see Grant McColley, *"The Book of Enoch* and *Paradise Lost," Harvard Theological Review* 31 (1938), 21-39. Interest in *Enoch* was revived in 1773 by Bruce's discovery of an Ethiopic translation. Hawthorne would have known of *Enoch* from his readings of James Bruce's *Travels to Discover the Source of the Nile* in 1833, and Hiob Ludolf's *A New History of Ethiopia* in 1836. Neither, however, contains the substance of the book. See Marion L. Kesselring, "Hawthorne's Reading," *Bulletin of the New York Public Library,* 53 (1949), 174, 195.

[8] Consider Wordsworth's comment: "I used to brood over the stories of Enoch and Elijah, and almost to persuade myself that, whatever might become of others, I should be translated, in something of the same way, to heaven," in his notes in "Ode" Intimations of Immortality from Recollections of Early Childhood," *Complete Poetical Works* (London: Macmillan, 1913), p. 358.

[9] J. A. Heraud and William Maginn, *"The Book of Enoch," Fraser's Magazine* 8 (November, 1833), 513-14. The passage from Young previously cited is included in this article, p. 530. This review concerns itself with the Romantic use of the angel lore of *Enoch,* principally by Byron and Moore.

[10] *Fraser's,* p. 528. Though Dimmesdale's role as Enoch and angel is ironic, elsewhere in Hawthorne's work he suggests that the capacity to link man with the angels is a poetic gift. Hawthorne's ideal preacher seems to be Ernest in "The Great Stone Face." In his simple communion with nature Ernest seems to be a companion of the angels, and he fulfills the role ascribed to the poet who shows "the golden links of the great chain that intertwined them with an angelic kindred; he brought out the hidden traits of celestial birth that made them worthy of such kin" (*The Snow Image* Vol. XI, Centenary Edition (Columbus: Ohio State University Press, 1974) pp. 43-44. In creating such images for people, Dimmesdale can be seen as reminding them of their better nature; unlike Ernest, he is not in harmony with himself.

[11] *Symbols of Transformation,* 2nd ed. (Princeton: Princeton University Press, 1967), p. 112.

A PRELIMINARY STUDY OF THE MACROBENTHOS OF WAVE-SWEPT AND PROTECTED SITES ON THE LAKE MICHIGAN SHORELINE AT TOFT POINT NATURAL AREA, WISCONSIN

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Abstract

The near-shore summer macrobenthos community was sampled at protected and wave-swept sites in Lake Michigan at the Toft Point Natural Area, Door County, Wisconsin. A total of 85 genera were found. Differences in the species composition at the two sites can be related to the influence of water motion on feeding mechanisms. Wave-swept sites were dominated by typically lotic organisms which feed by a collector/scraper mechanism including heptageniid and tricorythid mayflies and hydropsychid caddisflies. Protected sites were dominated by corixid and gerrid hemipterans, amphipods, isopods and gastropods. Predaceous invertebrates were rare at the wave-swept sites but more abundant in the community at protected sites. The number of genera at protected sites increased gradually through the summer while at the wave-swept sites, the highest number occurred in early July.

INTRODUCTION

In contrast to the deep water benthos, the macroinvertebrate community of the shallow, wave swept shores of the Great Lakes has been examined by very few investigators. Krecker and Lancaster (1933) and Shelford and Boesel (1942) studied the beaches of the wave zone in western Lake Erie. Barton and Hynes (1978a) made an extensive summer survey of this community in Lakes Ontario, Huron, Superior and Erie. In Lake Michigan, Wiley and Mozley (1978) noted the occurrence of typically sedentary benthos in the pelagial, near-shore area but at depths of 6-9 m. Lauritsen and White (1981), using artificial substrate samplers at water depths > 0.5 m, compared the benthos of two locations in Lake Michigan; a wave-swept, but still somewhat protected, rocky shoal habitat in the northeast and a man-made, rocky riprap site in the southeast.

The purpose of this study was to make a preliminary examination of the macrobenthos community of shallow water sites (< 1 m) in Lake Michigan. Specifically, the community structure and feeding habits of macroinvertebrates in wave-exposed areas was compared with that in protected areas.

SITE DESCRIPTION AND METHODS

The study was conducted at the Toft Point Natural Area on the northwest corner of Lake Michigan (Figure 1). Four sampling sites were selected, two on wave-swept shorelines (W1, W2) and two in protected areas (P1, P2). Sampling occurred four times in summer 1983: June 19, July 9, July 28-29, and August 19. On each sampling day, six to ten samples were collected within each site at depths from 0-1 m by thoroughly disturbing the sediment and rocks and then sweeping the area with a rectangular collecting net having a mesh

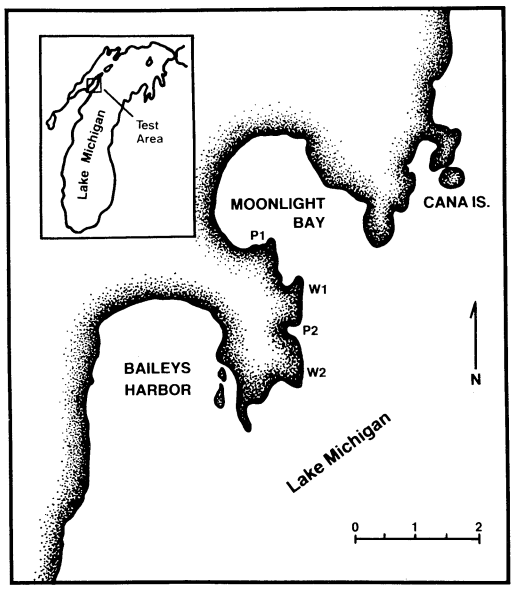

Fig. 1 Sampling sites on protected (P1, P2) and wave-swept (W1, W2) shores at Toft Point Natural Area.

size of 1 mm. Each sample was taken from an area of about 0.5 m^2. Large rocks were carried to shore where the organisms were picked off. Collection of additional samples continued until no new taxa were found, usually after about two hours. Because of the mesh size of the net used in collecting, small organisms such as Hydracarina, Oligocheata and some Chironomidae are underrepresented in these collections. Chironomids, in contrast to most other organisms, were not identified to the generic level and therefore were not included when determining number of genera present at a site. Specimens were preserved in 70-80% ethanol. Most organisms were identified to the generic level using Hilsenhoff (1981) and Merritt and Cumming (1978) for insects and Pennak (1978) for all others.

At sites W1 and W2, the bottom has a shallow slope with the one meter depth located approximately 40 meters from the water's edge. The substrate here consists of Silurian Dolomite bedrock with scattered areas of boulders in the deeper areas and scattered areas of boulders, cobble, and gravel in the shallower areas. Tufts of vegetation were present near the very edge of the shoreline. Some patches of *Cladophora* were present on rocks in the shallower water.

Site P1 was located in a large protected bay. The substrate consists largely of sand and the dominant vegetation was *Scirpus* sp. Site P2 was located in a small bay, essentially a pocket in back of the wave-swept shore. The substrate was mostly particulate organic matter and the odor of hydrogen sulfide could sometimes be detected while collecting. The vegetation here consisted largely of *Carex* sp.

Results

The major taxa found at each site are listed in Table 1. A complete list can be obtained from the authors. A total of 85 genera, exclusive of Chironomidae, were found at the four sites; 47 were found on the wave-swept shores and 60 in the protected areas. In many cases only a single individual of a genus was found at a site. If these are excluded because of their rarity, 29 genera were found on the wave-swept shores and 29 genera in the protected areas.

Two insect orders, Ephemeroptera and Trichoptera, and the Crustacean orders, Isopoda and Amphipoda, were numerically dominant on the wave-swept shores. Colonies of Porifera and Bryozoa were also quite abundant. The latter organisms were not reported by Barton and Hynes (1978a) nor observed in a more recent study of the shallow-water epilithic invertebrate community of Georgian Bay (Barton and Carter 1982). Hemipterans were not found and Coleopterans were rare; adults were collected only near shore. Trichoptera larvae dominated by the family Hydropsychidae were always present at all depths but were often more abundant in deeper water. The dominance of Ephemeroptera

TABLE 1. Major taxa collected at each site and their trophic categories (based on Merritt and Cummins 1978). Abundances are the maximum obtained during any one sampling: A ≥ 10 individuals, M = 3-9 individuals, R ≤ 2 individuals and NC = none collected.

	Trophic Category	*W1*	*W2*	*P1*	*P2*
Odonata					
Coenagrionidae	Predators	NC	NC	M	A
Plecoptera					
Acroneuria	Predators	NC	A	NC	NC
Ephemeroptera					
Stenonema	Collectors/Scrapers	A	M	NC	NC
other Heptageniids	Collectors/Scrapers	M	M	NC	NC
Leptophlebia	Collectors	A	A	R	M
Baetis	Collectors/Scrapers	A	A	M	R
Caenis	Collectors/Scrapers	A	M	M	NC
Tricorythodes	Collectors	M	A	M	R
Trichoptera					
Symphitopsyche	Collectors	A	A	NC	NC
Cheumatopsyche	Collectors	A	M	NC	NC
Helicopsyche	Scrapers	M	M	NC	NC
Leptoceridae	Shredders/Collectors	NC	NC	M	NC
Coleoptera					
Dytiscidae	Predators	M	R	NC	R
Laccobius	Plant piercers	NC	M	M	NC
Tropisternus (larvae)	Predators	NC	NC	R	A
Gyrinidae	Predators	NC	R	M	R
Hemiptera					
Sigara	Collectors/Plant piercers	R	NC	A	A
Trichocorixa	Predators	NC	NC	A	A
Corisella	Predators	NC	NC	A	NC
Notonecta	Predators	NC	NC	M	A
Gerris	Predators	NC	NC	A	A
Belostoma	Predators	NC	NC	NC	A
Diptera					
Chironomidae	Collectors	A	A	A	A
Antocha	Collectors	NC	M	NC	R
Haplotaxida					
Naididae*	Collectors	M	M	R	NC
Hirudinea					
Erpobdellidae*	Scavengers/Predators	M	M	R	NC
Amphipoda					
*Gammarus**	Scavengers	A	A	A	NC
*Hyalella azteca**	Scavengers	NC	R	A	A
Isopoda					
*Asellus**	Scavengers	A	A	A	M
Gastropoda					
*Physa**	Scrapers	A	A	M	M
*Gyraulus**	Scrapers	R	R	M	A
*Lymnaea**	Scrapers	NC	M	A	A
Porifera*	Collectors	A	A	NC	NC
Bryozoa					
*Plumatella**	Collectors	A	A	NC	NC

* Placed into trophic categories based on the feeding habits described in Pennak (1978).

(Caenidae, Baetidae, Heptageneiidae and Leptophlebiidae) and Trichoptera (Hydropsychidae) was also mentioned by Barton and Hynes (1978a) for shallow waters in Lake Huron and Georgian Bay. These authors reported the stonefly, *Acroneuria* (Perlidae), here collected at site W2, (in late July and August) from Lake Superior, Lake Huron and Georgian Bay but not from Lakes Erie or Ontario.

The protected sites were dominated by Hemiptera, Amphipoda, and Gastropoda. Corixid nymphs and adults were often extremely abundant. Most organisms were present at all depths out to the edge of the emergent vegetation. Beyond the emergent vegetation, very few specimens were collected. The benthos of the two protected sites had many similarities, but there were also some notable differences as might be expected considering one had sand (P1) and the other an organic substrate (P2). Trichopteran larvae with portable cases (Leptoceridae and Lepidostomatidae) were present at P1 but not P2. Site P1 also had more Ephemeroptera nymphs. Site P1 had large numbers of the amphipods *Gammarus* sp. and *Hyalella azteca* in late summer, while at site P2 only the latter was found and then in large numbers only in late summer.

Feeding habits of the organisms are an important aspect of the aquatic invertebrate community. Cummins' (1973) designation of trophic categories for aquatic insects based on their feeding habits was used to classify the major taxa found in this study (Table 1). The categories of collector, scraper, and plant piercer were lumped together because specimens were not keyed to the species level which is often necessary to distinguish among categories. In some cases it was still necessary to partition a genus between two of the categories. Invertebrates other than insects were not treated by Cummins, therefore scavengers were included as an additional feeding category to accommodate them.

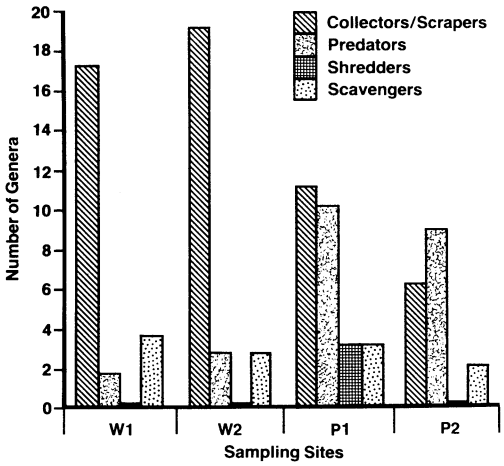

Fig. 2 Distribution of macrobenthos genera according to trophic categories (Cummins, 1973) at protected (P1, P2) and wave-swept (W1, W2) sampling sites at Toft Point Natural Area.

The importance of the various trophic categories in the community at each site is illustrated in Figure 2. Wave-swept sites are almost completely dominated both in diversity of genera and in abundance of individuals by collector/scrapers. These include the Ephemeroptera, *Heptagenia, Stenonema, Baetis* and *Tricorythodes,* and the Trichoptera, *Symphitopsyche* and *Cheumatopsyche.* Also observed in abundance were Porifera and Bryozoa, both of which utilize a collector-filterer type of feeding mode (Pennak, 1978). The only predator observed at the wave-swept sites was the stone fly, *Acroneuria.* Shredders were not found at either wave-swept site.

Both protected sites had fewer genera and lower abundance of collector/scrapers than the wave-swept sites. Predators, mostly Coenagrionidae (Odonata), Corixidae, Notonectidae, and Belastomatidae (Hemiptera), however, were much more abundant at protected sites. Shredders, represented primarily by Leptoceridae (Trichoptera) were observed at P1 but not P2.

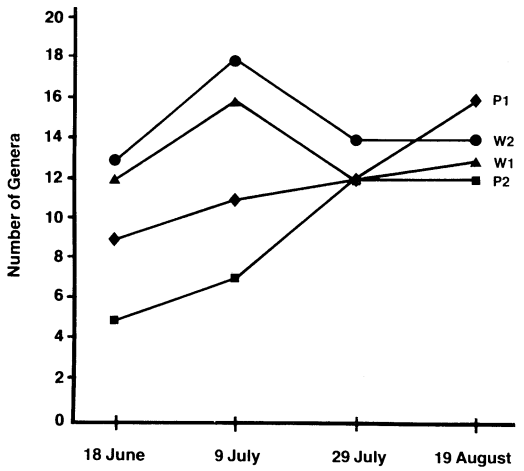

Fig. 3 Changes in number of genera of macrobenthos at protected (P1, P2) and wave-swept (W1, W2) sampling sites through the summer, 1982, Toft Point Natural Area.

Scavengers were present in similar numbers at all sites although P2, because of the absence of the amphipod, *Gammarus,* had the lowest abundance in this trophic category.

Significant changes in number of genera occurred in both types of habitats during the summer but at different times during the summer (Figure 3). At the wave-swept sites, the number of genera reached a maximum in early July. Genera which were rare or absent in mid-June but abundant or present in moderate numbers in early July were mostly collectors/scrapers including *Stenonema, Stenacron, Tricorythodes,* and a snail, *Physa.* Some prominent collector/scrapers such as *Leptophlebia, Caenis,* and *Cheumatopsyche* showed the opposite trend of large numbers of individuals in early summer but few or none in late summer. The predator *Acroneuria* was absent in early summer but abundant by late summer. Chironomids became more abundant through mid-summer followed by a decline at the last sampling.

At the protected sites, the number of genera continued to increase through the summer, reaching a peak at the last sampling. The increase was largely due to predators: adult *Gerris, Belostoma, Notonecta* and larval *Tropisternus.* These seasonal changes suggest fundamental differences in the trophic-dynamics of the communities at the two site types.

Discussion

Qualitative differences in the species composition at the two sites were evident. At the wave-swept sites, the macrobenthos consisted mainly of typically lotic species as noted also by Barton and Hynes (1978a). Adaptations for the lotic environment clearly are also advantageous in the wave-swept zone of large lakes. Lentic macrobenthos dominated at the protected sites.

It is clear that the benthos community structure is strongly influenced by water motion. The greater abundance and diversity of predators at protected sites suggests that most larger predators are better adapted for slow or standing waters. Indeed, in the wave-swept, marine rocky intertidal zone, it has been observed that predators often cannot forage effectively in highly exposed areas (Connell 1970, Dayton 1971). There is some evidence of mechanical limits to size in predators, and organisms in general, on wave-swept shores (Denny, et. al., 1985), but predators may be further hindered by a reduction in the efficiency of capture due to the turbulence.

The lack of predators in the wave-swept zone may have community-level ramifications. In the marine rocky intertidal, biological disturbance in the form of predation can control populations of dominant primary consumers, thus allowing less competitive species to exist (Paine 1966, Dayton 1971). Lubchenco (1978) and Sousa (1979) have shown that an intermediate level of disturbance, whether it be biological or physical (e.g., waves), tends to promote greatest diversity and abundance. The physical harshness of wave-swept sites on Lake Michigan, perhaps resulting in few

predators, might explain the lack of rare species here as contrasted to the protected sites.

Several factors could influence the temporal distribution of macrobenthos at the wave-swept sites. The increase in number of genera from June to early July could still be a part of a recovery process after scouring by spring storms and late winter ice abrasion. Recolonization of these shallow areas could take place from less disturbed areas (Wiley and Mozley 1978) or deep water refuges (Barton and Hynes 1978b). The mayfly, *Leptophlebia,* is known to migrate from deep waters before emerging (Edmunds et al. 1976). Increased abundance of epilithic algae in early summer could also explain the appearance in early July of such groups as *Physa, Helicopsyche,* and some Ephemeroptera.

The disappearance of some genera at the wave-swept sites in late July may be due to the turbulent harshness of the environment. It could also be explained by completion of life cycles, e.g. the immature Ephemeroptera, *Caenis, Leptophlebia,* and *Stenonema,* were all absent by late July. Competition or predation could similarly contribute to the decline. Barton and Hynes (1978a) suggested an upwelling of cold hypolimnetic water into the littoral zone can limit the distribution of some Ephemeroptera and Trichoptera species. One possible example of limitation due to temperature fluctuations in this study is in the Odonata. While their complete absence from the wave-swept shores is not unusual, their low abundance and diversity in the protected areas (particularly the Anisoptera) may be due to cold water intrusions or severe temperature fluctuations. Another factor to explain the disappearance or absence of certain groups may be the lack of deep substrate due to shallow underlying bedrock (Barton and Hynes 1978c). This would reduce the success of, or preclude colonization by, species which have a requirement for deep substrate in some part of their life cycle. It is noteworthy in this sense that the increase in number of predators in the protected sites by late summer was mainly due to adult Hemipterans, most of which are swimming-skating forms that are less dependent on a soft bottom substrate.

Conclusions

Differences in species composition of the macrobenthos community of wave-swept and protected sites can be related to the important influence of water motion on trophic relationships in the community. Specific adaptations and feeding mechanisms produce a unique assemblage of typically lotic organisms in the wave-swept zone. Examples include taxa from the families Perlidae, Heptageniidae, Tricorythidae, Hydropsychidae, and Pleuroceridae. Almost completely absent in this community are predaceous invertebrates. Reduced water turbulence in the protected areas allows the development of an invertebrate community more like those typically found in small lakes or ponds. Temporal changes in the number of genera present show a peak in early July for the wave-swept community and a gradual increase throughout summer for the protected community.

In view of the lack of studies on the wave-swept zone of large inland lakes, particularly Lake Michigan, we encourage further research. There is a need for a year-long study of the fauna; even Barton and Hynes (1978a) in their extensive study of the Canadian shores of the Great Lakes relied mainly on summer samples. Studies of disturbance caused by ice scouring and spring storms would be very interesting. These and others could provide valuable tests of theories concerning community organization developed in marine rocky intertidal communities.

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Literature Cited

Barton, D. R., and Hynes, H. B. N. 1978a, Wave-zone macrobenthos of the exposed Canadian shores of the St. Lawrence Great Lakes. J. Great Lakes Res. 4:27-45.

_____ and _____ 1978b. Seasonal variations in densities of macrobenthic populations in the wave-zone of north-central Lake Erie. J. Great Lakes Res. 4:50-56.

_____ and _____ 1978c. Seasonal study of the fauna of bedrock substrates in the wave-zone of Lakes Huron and Erie. Can. J. Zool. 56:48-54.

Barton, D. R., and Carter, J. C. H. 1982. Shallow-water epilithic invertebrate communities of eastern Georgian Bay, Ontario, in relation to exposure to wave action. Can. J. Zool. 60:984-993.

Connell, J. H., 1970. A predator-prey system in the marine intertidal region. I. *Balanus glandula* and several predatory species of *Thais*. Ecol. Monogr. 40:49-78.

Cummins, K. W. 1973. Trophic relations of aquatic insects. Ann. Rev. Entomol. 18: 183-210.

Dayton, P. K., 1971. Competition, disturbance, and community organization: the provision and subsequent utilization of space in a rocky intertidal community. Ecol. Monogr. 41: 351-388.

Denny, M. W., Daniel, T. L., and Koehl, M. A. R., 1985. Mechanical limits to size in wave-swept organisms. Ecol. Monogr. 55:69-102.

Edmunds, G. F., Jensen, S. L., and Berner, L. 1976. The mayflies of North and Central America, Univ. Minn. Press, Minneapolis.

Hilsenhoff, W. L. 1981. Aquatic insects of Wisconsin. Publication number 2. The Natural History Council, University of Wisconsin-Madison.

Krecker, F. H., and Lancaster, L. Y. 1933. Bottom shore fauna of western Lake Erie: a population study to a depth of six feet. Ecology 14:79-93.

Lauritsen, D. D., and White, D. S. 1981. Comparative studies of the zoobenthos of a natural and a man-made rocky habitat on the eastern shore of Lake Michigan. Univ. of Mich., Great Lakes Res. Div. Special Report No. 74, 65 pp.

Lubchenco, J., 1978. Plant species diversity in a marine intertidal community: importance of herbivore food preference and algal competitive abilities. Am. Nat. 112:23-39.

Merritt, R. W., and Cummins, K. W. 1978. An Introduction to the Aquatic Insects of North America. Kendall/Hunt. Publ., Dubuque.

Paine, R. T., 1966. Food web complexity and species diversity. Am. Nat. 100:65-75.

Pennak, R. W. 1978. Fresh-Water Invertebrates of the United States, 2nd Ed. John Wiley and Sons, New York.

Shelford, V. E., and Boesel, M. W. 1942. Bottom animal communities of the island area of western Lake Erie in the summer of 1937. Ohio J. Sci. 42:179-190.

Sousa, W. P., 1979. Disturbance in marine intertidal boulder fields: the non-equilibrium maintenance of species diversity. Ecology 60: 1225-1239.

Wiley, M. J., and Mozley, S. C. 1978. Pelagic occurrence of benthic animals near shore in Lake Michigan. J. Great Lakes Res. 4: 201-205.

SEASONAL MOVEMENTS OF WHITE-TAILED DEER ON DECLINING HABITATS IN CENTRAL WISCONSIN

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Abstract

Land use changes may impact winter habitats of deer from a central Wisconsin grassland area. During 1979-82, we used radio-telemetry to document seasonal movements and ranges of 19 deer from this area and adjacent wooded uplands. Home ranges appeared smallest during the fawning period and summer and largest during fall. Deer that summered in the wooded uplands occupied the same respective areas year round, but those from the open grassland area moved to the uplands mainly in early to mid-October and returned during mid-February through March. Deer in the study area probably will be affected negatively if their common winter (upland woods) habitat continues to be diminished.

INTRODUCTION

The 200-km² Buena Vista Marsh (BVM) is a unique grassland area in central Wisconsin that harbors white-tailed deer (*Odocoileus virginianus*) from late spring through fall. Wintering areas of deer from BVM are unknown; woodlots in surrounding uplands may serve as winter cover but these are being replaced by irrigated croplands (Butler 1978). The objective of this study was to obtain baseline data on seasonal movements and ranges of radio-marked deer from BVM and adjacent uplands. Habitat use by these deer was reported earlier (Murphy et al. 1985).

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STUDY AREA AND METHODS

The 327-km² study area includes 137-km² of the drained BVM in southwestern Portage County, Wisconsin, and 190 km² of adjacent uplands. The study area in BVM consists of 38% grassland and grass-shrub types (Kentucky bluegrass (*Poa pratensis*), quackgrass (*Agropyron repens*), goldenrod (*Solidago* spp.), willow (*Salix* spp.), and shrub-stage trembling aspen (*Populus tremuloides*), 31% open pasture, 23% cropland (corn, cash crops, and hay), and 8% small (15-60 ha) woodlots (aspen). The uplands consist of 42% woodlots and 10% shrub (both dominated by mixed oak (*Quercus* spp.), jackpine (*Pinus banksiana*), and aspen), 35%

cropland (corn, cash crops, and hay), and 13% idle fields and pasture. Soils are primarily flat sands from glacial outwash. Mean annual precipitation is 75 cm, including 110 cm of snow; mean annual temperature is 6°C with extremes of −42° and 42°C.

Deer were captured and marked throughout the study area and were radio-located almost daily as described in Murphy et al. (1985); multiple daily locations were collected during the deer hunting season. For movement data, we recognized 6 periods: spring (16 Feb-15 May), fawning (16 May-15 Jul), summer (16 Jul-15 Sep), fall (16 Sep-21 Nov), gun deer season (22-30 Nov), and winter (1 Dec-15 Feb).

The most frequented parts of an animal's home range have been termed "core areas" (CAs) (Ewer 1968:65). Isopleths that contained 67% of a season's radio-locations and that were defined by harmonic mean activity centers (Dixon and Chapman 1980) were used to define CAs in this study. Bucks that moved from their summer CAs during fall and that were shot during gun season were considered to be on their winter CAs based on our knowledge of movements of does that survived gun season. CA size for deer that used 2 CAs in a season was considered the sum of the areas.

Results and Discussion

We captured 29 deer during June 1979-February 1981; 10 were ear-tagged, and 19 were radio-collared and followed 2-30 months ($\bar{x} \pm SD = 8.5 \pm 7.0$) each during November 1979-November 1982. About 2,500 radiolocations were collected. Movement data were supported by observations of unmarked deer.

Deer that used BVM during summer (hereafter, "marsh deer") had separate winter CAs in the uplands that averaged 10.2 km (SD = 5.8) from their summer CAs (Fig. 1). Deer that used uplands as summer habitat (hereafter, "woods deer") maintained year round CAs.

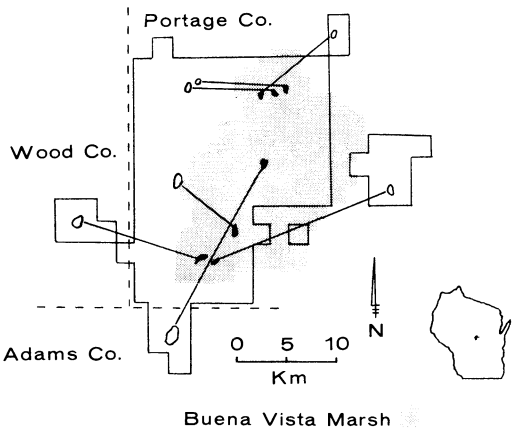

Fig. 1. Winter and summer core areas of 7 deer from the Buena Vista Marsh, Wisconsin, 1980-82.

Marsh deer moved to uplands mainly in early to mid-October (Table 1), perhaps in response to the 1st frosts. Oak mast probably attracted deer to uplands (Murphy et al. 1985). In spring, deer returned to BVM when successive daily temperatures reached 8-15° C, during mid-February through March following a mild winter (average Feb. and Mar. snow depths in 1981 were 8.0 and 0.0 cm, compared to 22.4 and 19.4 cm for 1961-77), and during April following a severe winter (average Feb. and Mar. snow depths in 1982 were 47.6 and 20.8 cm) (Table 1). Similarly, Hamerstrom and Blake (1939) reported that central Wisconsin deer move from their wintering areas during March and April, and move earlier after short, mild winters. In our study, spring movements appeared to coincide with the availability of green forage in open areas (Murphy et al. 1985).

Marsh deer winter CAs were in mixed upland woods mainly west of BVM (Fig. 1) and overlapped year round CAs of woods deer. Trail counts conducted on the study area after fresh snowfall (winter 1981-82) further suggest that deer winter almost exclusively in wooded uplands (D. Groebner, unpubl.). Irrigated cropland probably will

TABLE 1. Movement of radio-collared white-tailed deer to and from summer CAs (core areas) on the Buena Vista Marsh, Portage County, Wisconsin, 1980-82. S = Summer CA; W = Winter CA.

Deer no.	*Distance[a] (km)*	*Movement chronology*
Yearling females		
02	6.0	S-------WSW--SW----------S--------W------[b]
22	16.5	S-- --W?-[c]
23	20.0	S----------W-------S----------W----------S----------[d]
Adult females		
26	7.1	S-------WSWSWSW------SW-SWS---------- W-[b]
27	7.1	S-----W?-[c]
Yearling males		
12	4.8	S--------W----[b]
20	9.7	S--------W-----[b]
Months		J A S O N D J F M A-----S O N D J F M A-----S O N

[a] Distance between summer and winter CAs.
[b] Shot during deer hunting season.
[c] Killed on presumed winter CA by vehicle collision.
[d] Shot during deer season between winter and summer CAs.

continue to replace these upland habitats (Butler 1978). Deer make little use of irrigated cropland, probably because of inherent farming practices (Murphy et al. 1985). Thus, this change in land use may inimically impact deer.

Home Range Characteristics

Individual deer CA sizes varied considerably (Table 2), from 4 ha for an adult doe in upland woods during winter to 1,932 ha for a yearling buck in open grassland during fall. However, for statistical analyses, the data set was too fragmented by sex, age, habitat ("marsh" vs. "woods" deer), and season variables. Therefore, CA data and related movements are summarized descriptively.

Spring CAs appeared intermediate in size compared to other seasons (Table 2). Deer made frequent forays (0.7-2.9 km) to rye and cornfields (Murphy et al. 1985). During fawning period and summer, deer appeared to use relatively small areas (Table 2), probably because habitat needs were well met during these periods and, except for agricultural activity, deer were free from disturbance. Relatively small home range size during fawning-summer has been reported by others (Sparrowe and Springer 1970, Nelson and Mech 1981). Adult does appeared to use smaller areas than other deer during the fawning period, but they increased their movements during summer as their fawns became more mobile and social intolerance toward other deer presumably decreased (Ozoga et al. 1982).

Increased movements during early fall appeared to be food-related while those in late fall were associated with the rut. For exam-

TABLE 2. Seasonal core area sizes (ha, $\bar{x} \pm SD$) for radio-collared deer from the Buena Vista Marsh (marsh deer) and adjacent uplands (woods deer), Portage County, Wisconsin, 1980-81.

Sex and age classes[a]	*Season*					
	Spring	*Fawning season*	*Summer*	*Fall*	*Hunting season*	*Winter*
Marsh deer						
Yearling males	120 ± 103	94 ± 84	69 ± 22	881 ± 702	170	
(N deer, observations)	(4,92)	(4,122)	(4,141)	(4,197)	(1,17)	
Yearling females	116	37 ± 38	20 ± 22	152 ± 115	485 ± 535	149 ± 161
(N deer, observations)	(1,21)	(3,85)	(3,91)	(3,145)	(2,42)	(2,56)
Adult females	233 ± 98	18 ± 3	84 ± 98	134	89	4
(N deer, observations)	(3,67)	(2,54)	(2,70)	(1,41)	(1,21)	(1,25)
Woods deer						
Fawn female[b]				5	14	9
(N observations)				(36)	(17)	(22)
Yearling males	62 ± 14	232[c]	56	53		
(N deer, observations)	(3,80)	(1,24)	(1,25)	(1,26)		
Yearling females	56 ± 1	61	12	27	41	
(N deer, observations)	(2,62)	(1,25)	(1,25)	(1,31)	(1,21)	
Adult male	310	56	51	270	47	
(N observations)	(35)	(27)	(35)	(40)	(10)	

[a] Age class based on age at fawning season (e.g., "yearlings" are about 0.8 and 1.0 years old during spring and fawning season, respectively).

[b] Data were collected during fall-winter, 1979-80.

[c] Dispersed during fawning season and did not establish a home range until summer.

ple, a yearling buck moved (28 Sep and 6 Oct) 4.0 km from his CA at BVM to a 65-ha cornfield where he remained 3-4 days. Two other yearling bucks wandered extensively over 35-km² areas at BVM during late fall. Both bucks and does at BVM made irregular movements during rut, but those of bucks seemed more frequent and extensive (Table 2), as Downing and McGinnes (1975) noted for white-tails in Virginia.

Deer response to hunter pressure during gun season varied. One adult and 1 yearling buck reduced their activity to within small, heavily wooded CAs (Table 2) and survived 5 and 7 days, respectively, of the 9-day gun season. Four yearling bucks responded to drives by crossing open areas and were shot on the 1st day of gun season. Does and fawns exhibited strong home range fidelity; hunters drove them 0.5-9.0 km from their CAs, but they returned at night.

During winter, deer made regular feeding trips (0.4-1.0 km) to hay and to cornfields. The winters of 1979-80 and 1980-81 were mild (average Dec., Jan., and Feb. snow depths were 1.5, 3.8, and 7.9 cm compared to the 1961-77 averages 9.1, 24.3, and 22.4 cm) and deer probably would have smaller CAs (Table 2) in more severe winters.

SUMMARY AND CONCLUSIONS

We observed 2 behavioral patterns on the study area: woods deer fulfill their needs on year round CAs in uplands adjacent to BVM; marsh deer fulfill their food and cover needs at BVM during spring through fall, but move to surrounding uplands to fulfill these needs during winter. Seasonal movements of marsh deer suggest these deer may be considered migratory, while woods deer appear sedentary.

Sizes of areas used by deer appeared

largest in fall and smallest during the fawning period and summer. Seasonal changes in CA size and movements seemed related to factors documented in other studies.

Deer that move from BVM supplement fall populations, and thus the hunting harvest, of deer in adjacent uplands. Similarly, movement of deer from some refuges is important to the deer harvest in surrounding areas (Hawkins et al. 1971, Kammermeyer and Marchinton 1976). We predict that deer harvests at BVM and in surrounding uplands will decrease if winter (upland woods) habitat continues to be removed and trends in local farming practices remain unchanged.

Literature Cited

Butler, K. S. 1978. Irrigation in the central sands of Wisconsin: potentials and impacts. Univ. Wis. Coll. Agric. and Life Sci. Res. Bull. R2960. 51 pp.

Dixon, K. R., and J. A. Chapman. 1980. Harmonic mean measures of animal activity areas. Ecology 61:1040-1044.

Downing, R. L., and B. S. McGinnes. 1975. Movement patterns of white-tailed deer in a Virginia enclosure. Proc. Southeast. Asso. Game and Fish Comm. 29:454-459.

Ewer, R. F. 1968. Ethology of mammals. Logos Press, London. 418 pp.

Hamerstrom, F. N., Jr., and J. Blake. 1939. Winter movements and winter foods of white-tailed deer in central Wisconsin. J. Mammal. 20:206-215.

Hawkins, R. E., W. D. Klimstra, and D. C. Autry. 1971. Dispersal of deer from Crab Orchard National Wildlife Refuge. J. Wildl. Manage. 35:216-220.

Kammermeyer, K. E., and R. L. Marchinton. 1976. Notes on dispersal of male white-tailed deer. J. Mammal. 57:776-778.

Murphy, R. K., N. F. Payne, and R. K. Anderson. 1985. White-tailed deer use of an irrigated agriculture-grassland area in central Wisconsin. J. Wildl. Manage. 49:125-128.

Nelson, M. E., and L. D. Mech. 1981. Deer social organization and wolf predation in northeastern Minnesota. Wildl. Monogr. 77. 53 pp.

Ozoga, J. J., L. J. Verme, and C. S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer: impact on neonatal mortality. J. Wildl. Manage. 46:1-11.

Sparrowe, R. D., and P. F. Springer. 1970. Seasonal activity patterns of white-tailed deer in eastern South Dakota. J. Wildl. Manage. 34:420-431.

NEW DISTRIBUTIONAL RECORDS FOR WISCONSIN AMPHIBIANS AND REPTILES

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Abstract

Twenty distributional records are provided for thirteen species of Wisconsin amphibians and reptiles. Most represent new county records.

INTRODUCTION

The geographic distribution of the Wisconsin herpetofauna was summarized most recently by Vogt (1981), with additional records provided by Cochran (1982 a,b,c, 1983 a,b), Cochran and Hodgson (1985, 1986), Cochran et al. (in press), and Hodgson and Cochran (1986). The purpose of this paper is to provide new distributional information for several Wisconsin amphibian and reptile species. Not only do these records fill distributional hiatuses, but they serve to document the existence of species at particular points in time and space. Such information can be used as baseline data to compare with future observations.

The following format has been used to report each new record: scientific name, common name (after Collins et al. 1982), locality, date of collection, collector(s), place of deposition and catalog number (where appropriate), and comments. Unless otherwise specified, each specimen described below represents the first published record for its respective county, based on Vogt (1981) and additional references cited in Cochran (1982d). All specimens except the *Crotalus* were verified by one or both authors.

CAUDATA

Ambystoma laterale (Blue-spotted salamander). (1) Sawyer County: one found beneath a piece of bark in woods on northeast side of confluence of Mosquito Brook with Namekagon River (T41N,R9W,S12). 22 Sep 1983. Cochran, Lyons. Total length: 106 mm, snout-vent length: 57 mm. Erythrocyte area (Austin and Bogart 1982): $\bar{X} = 728.9$ μm^2, $N = 10$, range = 589.0-809.9 μm^2. Described as uncommon by Briggs and Young (1976) for nearby Pigeon Lake region in Bayfield Co. (2) Burnett Co: Five individuals found beneath logs near wooded vernal pool at wayside park along St. Croix River on south side of Hwy. 70 (T38N, R20W,S24). 25 May 1984. Cochran, Lyons. Photograph in University of Wisconsin-Madison Zoology Museum (UWZ) collection (Accession Number 84-147). (3) Marinette Co: two individuals found beneath a log at Bear Point Landing on the Menominee River along Hwy 180; one was preserved. 24 Jul 1986. Cochran, J. A. Cochran. UWZ H22633.

Ambystoma tremblayi (Tremblay's salamander). Vilas Co: One beneath a rock at edge of driveway at University of Wisconsin Trout Lake Station (T41N,R7E,S19). 1 Oct

1983. Cochran, J. Freedman, Lyons. Photographed (UWZ Accession Number 84-147). Total length: 13.5 cm; snout-vent length: 73 cm. Erythrocyte area (Austin and Bogart 1982): $\bar{X} = 1025.9$ μm^2, $N = 10$, range 917.9-1119.2 μm^2. Diffuse blue coloring along sides. Reported by Vogt (1981) for adjacent Oneida and Price Counties. Lyons observed several additional specimens in spring 1984, in a small vernal pool next to the Trout Lake Station Laboratory. The only specimen captured had a small fingernail clam attached to one toe (see Davis and Gilhen 1982).

Hemidactylium scutatum (Four-toed salamander). (1) Vilas Co: Found beneath a log near wooded pool adjacent to Trout Lake Station Laboratory. (T41N,R7E,S19). 1 Oct 1983. J. Freedman, Cochran, and J. D. Lyons. Vogt (1981) listed an unconfirmed record for adjacent Forest Co, and Robinson and Werner (1975) reported its presence in Michigan's Upper Peninsula. (2) Portage Co: In woods on south side of Blackberry Hill Road (T23N,R7E,S19). 22 Jun 1985. Cochran, with J. A. Cochran, A. G. Cochran, D. Watson. Preserved in St. Norbert College Biology Department reference collection. Previously reported from the opposite end of Portage Co by Vogt (1981). This record is included because of the relative paucity of records for this elusive species and because it corresponds to what is apparently atypical habitat (upland forest, no boggy habitat in the vicinity). Other species collected include a single *Bufo americanus* and numerous *Plethodon cinereus*.

Necturus maculosus (Mudpuppy). (1) Richland Co: Wisconsin River (T8M,R1E, S5), 100 m upstream of public boat landing on north side of river. 13 Apr 1985. David J. Heath. UWZ H22610. (2) Crawford Co: Caught in hoopnet in Wisconsin River just downstream from Hwy 18/35 bridge (T6N, R6W,S14). 15 Apr 1985. Lyons, S. Landon, T. Pellett.

ANURA

Pseudacris triseriata (Chorus frog). Sawyer Co: One adult and several tadpoles preserved from Airport Road between Hwy 63 and Namekagon River (T41N,R9W,S23). 23 May 1984. Cochran, Lyons. UWZ H22578. This species was heard calling from several wetlands along Airport Road, with *Hyla crucifer, Rana pipiens,* and *R. sylvatica* also present. Described as common by Briggs and Young (1976) for the nearby Pigeon Lake region in Bayfield Co.

TESTUDINES

Chelydra serpentina (Common snapping turtle). (1) Green Co: Small adult in Sugar River, just upstream from Ten Eyke Road Bridge near Brodhead (T2N,R9E,S26/35). 16 Jun 1983. Cochran, Lyons, F. J. Rahel. (2) Trempeleau Co: juvenile recently killed on Hwy 54/35 just south of Trempeleau River. 30 Apr 1985. Cochran. UWZ H22634. Substantiates record in Vogt (1981) not based on examined specimen.

Clemmys insculpta (Wood turtle). Sawyer Co: Confluence of Mosquito Brook with the Namekagon River (T41N,R9W,S12). 23 May 1984. Lyons, Cochran. Photographed (UWZ Accession Number 84-147). Included on the list of state threatened species. Previously reported from the northwest corner of Sawyer Co by Vogt (1981).

Emydoidea blandingii (Blanding's turtle). Jackson Co: Recently killed on Hwy 54 about 1.5 km. east of Kirch Road. 30 April 1986. Cochran. UWZ H22635. Substantiates record in Vogt (1981) not based on examined specimen.

Trionyx muticus (Smooth softshell turtle). Grant County: Collected in fish seine from main channel of Mississippi River, Pool 11, River Mile 605. 6 May 1946. J. Greenbank. Originally included with a preserved sample of fishes (MR 132), but now recatalogued separately as UWZ H22581. First published

record from Pool 11 (Vogt 1981, Williams and Christiansen 1981).

Trionyx spiniferus (Spiny softshell turtle). Pierce Co: (1) Collected in fish seine from Mississippi River, Pool 4, center of back channel approximately 0.4 km below Goose Lake outlet. 5 Sep 1947. Miron and Monson. Originally included with a preserved sample of fishes (MR 228), but now recatalogued separately as UWZ H22579. (2) Collected in fish seine from Mississippi River, Pool 3, Wisconsin shore of main channel near Diamond Bluff. 26 Sep 1947. Miron and Monson. Originally included with a preserved sample of fishes (MR 238), but now recatalogued separately as UWZ H22580.

Serpentes

Heterodon platyrhinos (Eastern hognose snake). (1) Wood County: Found freshly killed at ca 2300 h on Hwy 54 about ¼ km south of G.B. & W railroads tracks. 6 Aug 1980. Cochran. Many small anurans were observed hopping on the road in the same general area after the passage of scattered thunderstorms. Although Vogt (1981) stated that this snake is most abundant in Wisconsin's central "sand counties," he included no record for Wood Co. (2) Jackson Co: adult recently killed on Hwy 54, just west of north turnoff for Co Road K. 30 Apr 1986. Cochran. UWZ H22636. Substantiates records in Vogt (1981) not based on examined specimens.

Storeria occipitomaculata (Redbelly snake). Sawyer Co: Federal campsite on Namekagon River just downstream from Hwy 63 crossing (T42N,R8W,S31). 20 Sep 1983. Cochran, Lyons. Photographed (UWZ Accession Number 84-147). Described as common by Briggs and Young (1976) for nearby Pigeon Lake region in adjacent Bayfield Co.

Crotalus horridus (Timber rattlesnake). On 24 Jul 1983, a girl was bitten by a timber rattlesnake just south of Somerset, St. Croix Co (Keyler 1983). St. Croix Co was not included by Vogt (1981) within the current range of the timber rattlesnake on the basis of recent records, but it was included within the historical range by Schorger (1967-68).

Acknowledgments

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Literature Cited

Austin, N. E. and J. P. Bogart. 1982. Erythrocyte area and ploidy determination in the salamanders of the *Ambystoma jeffersonianum* complex. Copeia 1982:485-488.

Briggs, J. and H. Young. 1976. Amphibians and reptiles of the Pigeon Lake region. Trans. Wis. Acad. Sci., Arts and Lett. 56:29-48.

Cochran, P. A. 1982a. Geographic distribution: *Necturus maculosus*. SSAR Herp. Review 13:79.

_____. 1982b. Geographic distribution: *Rana catesbeiana*. SSAR Herp. Review 13:79-80.

_____. 1982c. Geographic distribution: *Trionyx spiniferus*. SSAR Herp. Review 13:80.

_____. 1982d. A supplemental bibliography of publications pertinent to the Wisconsin herpetofauna. Bull. Chicago Herp. Soc. 17:105-108.

_____. 1983a. Geographic distribution. *Coluber constrictor*. SSAR Herp. Review 14:123.

_____. 1983b. Geographic distribution: *Nerodia sipedon*. SSAR Herp. Review 14:124.

_____ and J. R. Hodgson. 1985. Geographic distribution: *Emydoidea blandingii*. SSAR Herp. Review 16:116.

_____ and J. R. Hodgson. 1986. Geographic distribution: *Ambystoma laterale*. SSAR Herp. Review 17:26.

_____, J. R. Hodgson and R. M. Korb. 1986. New distributional records for reptiles and amphibians in Brown County, Wisconsin. SSAR Herp. Review (in press).

Collins, J. T., R. Conant, J. E. Huheey, J. L. Knight, E. M. Rundquist and H. M. Smith. 1982. Standard common and current scientific names for North American amphibians and reptiles (Second edition). SSAR Herp. Circular No. 12, 28 pp.

Davis, D. S. and J. Gilhen. 1982. An observation of the transportation of pea clams, *Pisidium adamsi,* by blue-spotted salamanders, *Ambystoma laterale.* Can. Field-Nat. 96:213-215.

Hodgson, J. R. and P. A. Cochran. 1986. Geographic distribution: *Hyla crucifer.* SSAR Herp. Review 17:26.

Keyler, D, E, 1983. Letter to editor. Minn. Herp. Soc. Newsl. 3(8):2.

Robinson, W. L. and J. K. Werner. 1975. Vertebrate animal populations of the McCormick Forest. USDA For. Serv. Res. Pap. NC-118, North Cent. For. Exp. Stn., St. Paul, Minn. 25 pp.

Schorger, A. W. 1967-68. Rattlesnakes in early Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 56:29-48.

Vogt, R. C. 1981. Natural history of amphibians and reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wis. 205 pp.

Williams, T. A. and J. L. Christiansen. 1981. The niches of two sympatric softshell turtles, *Trionyx muticus* and *Trionyx spiniferus,* in Iowa. J. Herp. 15:303-308.

FOREST FLOOR BIOMASS AND NUTRIENTS IN RED MAPLE (*Acer rubrum* L.) STANDS OF WISCONSIN AND MICHIGAN

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Abstract

The forest floors of 60 even-aged red maple stands were sampled in northern Wisconsin and Michigan. Dry weights and nutrient contents were determined for the Oi + Oe and Oa horizons, as well as for the total forest floor. All data were arranged into three soil productivity groups based on site index (18.9, 17.6 and 14.9m). The greatest forest floor dry weight and nutrient contents were associated with the highest soil productivity group. The lowest group, which consisted of the dry, sandy outwash sites, had the smallest forest floor dry weights and nutrient storage. The bulk of the dry weight and nutrient content of the forest floor was in the Oa horizon.

INTRODUCTION

Red maple (*Acer rubrum* L.) is a tree species of interest to many foresters in the Lake States. Crow and Erdmann (1983) estimated that red maple is now an important component on more than 400,000 ha in the Lake States. Red maple is a moderately tolerant species, a prolific sprouter and seed producer, and a fast grower. All of these characteristics have allowed it to become a strong competitor for the growing space vacated by American elms (*Ulmus americana* L.) killed by Dutch elm disease. Red maple occurs on a variety of sites ranging from dry to wet, but is most abundant in dry-mesic sites (Curtis 1959).

The forest floor represents an important component of a forest ecosystem. It provides a niche for a variety of microflora and fauna, a seedbed for forest vegetation, and nutrients that are continuously made available for plant growth through mineralization processes (Pritchett, 1979). In addition, the forest floor stores water and reduces runoff. Early forest floor studies in this country focused on classification for inventory purposes (Romell and Heiberg 1931, Heiberg and Chandler 1941), while more recent investigations have dealt with such topics as nutrient release through decomposition (Aber and Melillo 1980). The forest floor has recently been recommended for classifying forest ecosystems (Snyder and Pilgrim 1985). There is still a need for forest floor information for various timber types in the Lake States. As soil surveys increase in scope and as forest management intensifies to include practices such as drainage, fertilization, and prescribed fire, the need for additional information on soil-site classification and nutrient cycling in forest ecosystems will become more pressing.

The information presented here is part of a larger, regional study investigating soil-site relationships of red maple. The specific objective is to report forest floor dry weight, depth, and macro- and micronutrient contents associated with red maple stands growing on three soil productivity groups in northern Wisconsin and Michigan.

METHODS

Sixty even-aged red maple stands were located throughout northern Wisconsin and Michigan (Table 1). The stands were all fully-stocked, and originated from seeds

TABLE 1. Mean stand conditions for three soil productivity groups in northern Wisconsin and Michigan[1]

Soil Productivity Class	*No. Stands*	*Stand Age (Yrs)*	*Site Index (m)*	*Basal Area (m^2/ha)*	*Stand Biomass (t/ha)*	*Mean Annual Biomass Increment (t/ha/yr)*
I	22	62a	18.9a	31.4a	222a	3.6a
II	18	66a	17.6b	31.4a	220a	3.4a
III	20	67a	14.9c	28.4a	184b	2.8b

[1] Means within a column followed by the same letter are not significantly different at the 0.05 level.

rather than stump sprouting. They occur on a variety of parent materials, including lacustrine sediments, glacial till, and glacial outwash. The soil moisture regimes ranged from dry mesic to mesic.

Within each stand two 1,000 m^2 plots were established. Site index was obtained from stem analysis of at least two dominant or co-dominant trees per plot. Biomass was computed from dbh measurements using equations developed by Crow (1983). In each stand a soil pit was dug to a depth of 2 m and described by horizons. A 0.25 m^2 forest floor sample was collected near each pit, separated into Oi + Oe and Oa horizons, and returned to the lab for analysis.

In the lab the Oi + Oe samples were oven-dried at 65°C, then ground in a Wiley mill to pass a 1 mm sieve. The Oa samples were dried and gently passed through a 2 mm sieve; organic material not passing through the sieve was ground in a Wiley mill and remixed with the rest of each sample. All forest floor samples were digested in concentrated nitric and perchloric acid, and total P, K, Ca, Mg, S, B, Mn, Zn, Cu, and Fe were

TABLE 2. Mean dry weight, nutrient contents, and depth for the total forest floor (Oi + Oe + Oa horizons) for three soil productivity groups[1]

	PRODUCTIVITY GROUP					
	I		*II*		*III*	
variable	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
	kg ha^{-1}					
Dry wt.	45,752 a	15,858	44,636 a	18,163	29,182 b	9,159
N	565 a	314	458 b	210	294 c	126
P	37 a	12	31 b	11	21 c	7
K	38 a	11	30 b	11	20 c	7
Ca	210 a	105	164 b	65	100 c	37
Mg	38 a	19	33 a	20	18 b	10
S	54 a	28	46 a	24	29 b	13
Zn	3.0a	1.6	2.4b	1.7	1.2c	0.6
B	0.6a	0.2	0.5a	0.2	0.3b	0.1
Mn	40.1a	73.2	23.6a	18.5	21.9a	13.7
Fe	162.8a	114.7	159.0a	149.6	67.1b	34.7
Cu	0.8a	0.5	0.6b	0.3	0.4c	0.2
depth (cm)	9.2a	3.6	9.5a	2.9	7.5b	2.4

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

determined using a Model 34000 ARL plasma emission spectrophotometer at the University of Wisconsin-Madison. Total N was determined on ground subsamples at the University of Wisconsin-Stevens Point using the semi-micro Kjeldahl procedure.

During the field sampling phase of the study, site productivity differences associated with soil parent material and drainage class became apparent. Two measures of productivity, site index and mean annual biomass increment, were subjected to cluster analysis using Ward's hierarchical method (Ward 1963). Three distinct groups were produced, and forest floor dry weights and depths were stratified by group and subjected to an analysis of variance followed by mean separation using Duncan's Multiple Range Test at the 0.05 level. All statistical analyses were performed using SPSS on the Burroughs B6900 mainframe computer at the University of Wisconsin-Stevens Point.

Results and Discussion

The three soil productivity groups sampled differred primarily in soil parent material and drainage class. The highest group had a mean site index of 18.9 m, and consisted of the lacustrine soils and till soils that were moderately well-drained. The intermediate group had a mean site index of 17.6 m and consisted of other glacial till soils and the wet outwash soils. The lowest productivity group had a mean site index of 14.9 m and consisted of the dry glacial outwash sites.

In general, the highest soil productivity group contained the largest forest floor biomass with the greatest amount of associated nutrient storage (Table 2). For example, soil productivity group I had an average forest floor dry weight of 45,752 kg/ha. This was not different from the 44,636 kg/ha associated with group II, but was significantly higher than the 29,182 kg/ha found with the group III sites. Significant differences were also found with N,P,K,Ca,Mg,S,Zn,B, Fe, and Cu (Table 2). The same trend was exhibited with Mn, however, the differences were not significant.

The greatest dry weight and associated nutrient storage was found in the Oa horizon (Tables 3,4). This was due in part to the associated mineral matter which forms an integral part of the Oa horizon. The large amounts of Fe found in the Oa are most likely associated with this mineral soil. The Oa horizon comprised 69%, 75%, and 70% of the total forest floor dry weight for soil productivity groups I, II, and III respectively. Although the Oa horizon on group II sites had a slightly higher dry weight than on group I sites, the group I sites had higher nutrient contents, indicating a higher nutrient concentration in the group I Oa horizons.

The association between low (moist) drainage conditions and higher forest floor dry weights and nutrient contents has been documented in the literature (Mader et al. 1977, Reiners and Reiners 1970, Perala and Alban 1982). In this study the group I and II sites were noticeably wetter than the dry, sandy outwash group III sites, which partially explains the larger forest floor dry weights and nutrient contents on those sites. In addition, above-ground biomass production and litterfall have been observed to be lower on sandy, infertile sites in the Lake States (Perala and Alban 1982).

Conclusion

This study showed that the higher quality red maple sites investigated had greater forest floor dry weights with greater associated macro- and micronutrients, and occurred on mesic to moist sites. The poorest quality sites, which occurred on the dry outwash sands, had forest floors that were significantly lower in dry weight and nutrient content. Management practices that are likely to impact the forest floor (i.e. site preparation, prescribed burning) should be practiced with more care on the group III

TABLE 3. Mean dry weight and nutrient contents for the Oi + Oe forest floor horizons for three soil productivity groups[1]

	PRODUCTIVITY GROUP					
	I		*II*		*III*	
variable	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
	kg/ha					
Dry wt.	14,286 a	8,670	11,233 b	5,783	8,666 c	4,441
N	218 a	155	179 b	104	131 c	63
P	13 a	7	10 a	5	9 a	4
K	13 a	8	11 a	7	9 a	4
Ca	111 a	54	92 a	33	70 b	29
Mg	11 a	7	9 ab	4	7 b	3
S	20 a	15	16 a	11	12 a	6
Zn	1.0a	0.7	0.7ab	0.4	0.4b	0.3
B	0.2a	0.1	0.2ab	0.1	0.1b	0.1
Mn	10.9a	4.9	12.0a	7.5	13.3a	6.1
Fe	14.2a	10.1	12.8ab	8.6	7.2b	4.8
Cu	0.2a	0.1	0.1ab	0.1	0.1b	0.1

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

TABLE 4. Mean dry weight and nutrient contents for the Oa forest floor horizons for three soil productivity groups[1]

	PRODUCTIVITY GROUP					
	I		*II*		*III*	
variable	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
	kg ha^{-1}					
Dry wt.	31,466 ab	9,516	33,402 b	16,472	20,516 a	6,482
N	347 a	188	279 ab	158	163 b	83
P	25 a	11	20 ab	10	13 b	4
K	25 a	12	19 ab	8	11 b	5
Ca	99 a	75	72 ab	46	30 b	14
Mg	27 a	18	24 ab	20	11 b	7
S	34 a	18	29 ab	20	17 b	8
Zn	2.1a	1.3	1.7ab	1.5	0.8b	0.4
B	0.3a	0.1	0.3a	0.1	0.2b	0.1
Mn	29.2a	73.5	11.5a	17.8	8.7a	11.5
Fe	148.7a	115.3	146.2a	151.5	60.0b	32.7
Cu	0.6a	0.4	0.5ab	0.3	0.3b	0.2

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

sites and nutrient conservation measures should be followed (Bengston 1981).

Literature Cited

Aber, J. D. and J. M. Melillo, 1980. Litter decomposition: measuring relative contributions of organic matter and nitrogen to forest soils. Can. J. Botany 58:416-421.

Bengston, G. W. 1981. Nutrient conservation in forestry: a perspective. South. J. Appl. Forest. 5:50-59.

Crow, T. R. 1983. Comparing biomass regression by site and stand age for red maple. Can. J. For. Res. 13:283-288.

_____ and G. G. Erdmann. 1983. Weight and volume equations and tables for red maple in the Lake States. U.S.D.A. For. Serv., North Cen. For. Exp. Sta. Res. Pap. NC-242. 14 p.

Curtis, J. T. 1959. The vegetation of Wisconsin. Univ. Wisconsin Press, Madison. 657 p.

Heiberg, S. O. and R. F. Chandler. 1941. A revised nomenclature of forest humus layers for the northeastern United States. Soil Science 32:87-99.

Mader, D. L., H. W. Lull, and E. I. Swenson. 1977. Humus accumulation in hardwood stands in the Northeast. Mass. Agr. Exp. Sta. Res. Bull. No. 648. Univ. Mass, Amherst. 37 p.

Perala, D. A. and D. H. Alban. 1982. Rates of forest floor decomposition and nutrient turnover in aspen, pine, and spruce stands on two soils. U.S.D.A. For. Serv. North Cen. For. Exp. Sta. Res. Pap. NC-227. 5 p.

Pritchett, W. L. 1979. Properties and management of forest soils. John Wiley & Sons. New York, 500 p.

Reiners, W. A. and N. M. Reiners. 1970. Energy and nutrient dynamics of forest floors in three Minnesota forests. J. Ecol. 58:497-519.

Romell, L. G. and S. O. Heiberg. 1931. Types of humus layer in the forests of northeastern United States. Ecology 12:567-608.

Snyder, K. E. and S. A. L. Pilgrim. 1985. Sharper focus on forest floor horizons. Soil Survey Horizons 26:9-15.

Ward, J. H. 1963. Hierarchical grouping to optimize an objective function. J. Amer. Stat. Assoc. 58:236-244.

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