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Volume 69, 1981

Co-editors
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TRANSACTIONS OF THE WISCONSIN ACADEMY

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Reid Bryson

MODERN PROPHECY AND THE ACADEMY

Reid Bryson

Presidential Address

April 1981

The theme of this meeting has been "The Sciences, Arts and Letters in the 1980s." I have not heard any comments to the effect that that constitutes a forecast, or prophecy if you will, for we are only a third of the way into 1981. Why not? I believe it is because this is one of those times in history when people are interested in analysis and prediction, and are exposed to prediction and analysis (some cases instant) every day. The news this week included discussion of "leading economics indicators," measures which are supposed to have a predictive capability with respect to the future state of the economy. The latest issue of *Science* contains a discussion of recoverable domestic petroleum reserves, in the context of prediction of when the oil will run out and what our future dependence on imported petroleum will be. With the successful flight of the "Columbia" we heard repeated "predictions" (which I question) of space colonization, lunar mining and the like.

Along with many varieties of prediction in the media we have available, in almost any magazine we pick up, long articles of an analytical nature. How systems work and what they mean must be interesting to large segments of the population or profit-oriented publishers would not print so many examples. Is this different than the Now generation and instant gratification period of the sixties and early seventies? I think so.

I recently visited the Walt Disney Studios in California as a consultant on a new set of exhibits for Disney World. They are building a very expensive layout called the "Experimental Prototype Community of Tomorrow." It is predictive and analytical. There is no question, when one looks at the financial and attendance aspects of Disney World, but that the people involved in the production know what "turns on" the American public as well as huge numbers of foreign visitors. One of my colleagues on this visit to California was Dr. John Gibbons, Director of the Congressional Office of Technology Assessment. He believes that there is, both in Congress and the general public, intense interest in analysis of the world about us and in where things lead us into the future. At the same time there is a great deal of anti-intellectualism and a stupendous amount of misinformation in circulation. That is where the Wisconsin Academy enters the picture, as I shall indicate later.

I've been involved in prediction and scientific prophesy all my adult life, both short-range and long-range. My first experience with operational weather forecasting in 1944 involved a typhoon. Another Air Corps Officer, Bill Plumley, and I were assigned to work at the Navy Weather Central in Hawaii, and our job was to produce a weather forecast for a fleet air strike against Marcus Island. We were working with a junior Navy officer who had been one of my students at the University of Chicago. We had all day to make the forecast, but very little data on which to base the forecast. It was obvious from the beginning, however, that we had to decide how a typhoon would move in the next two days.

During the day we devised a method for constructing an upper air chart using surface observations from ships and islands, built a slide rule to make the calculations, drew the upper air chart which was needed to estimate the movement of the typhoon and concluded that it would not move safely straight westward, but would curve northward towards Marcus Island and the fleet. Just before we were able to send the forecast to the Admiral, the very senior officer in charge of the weather central came in—very drunk. He looked at the forecast for 20 seconds and said, "Typhoons never recurve at this time of the year. Change the forecast." There is only one answer to a senior officer—"Yes, Sir!" He was wrong. The typhoon met the fleet. As I recall about half a dozen aircraft and crews were lost as a consequence. That was the beginning of my nearly four decades of concern with careful analysis and responsible prediction. It was also a rude introduction to what I call anti-intellectualism and misinformation today.

My next prediction of importance involving a typhoon was a much worse case of ignorance or failure to use available knowledge. I had been following a probable typhoon across the Pacific for ten days. When it passed south of Guam it was quite evident that the "probable" had to be changed to "certain." I ordered a reconnaissance by air, and the aircrew radioed back from the eye that it was very severe and gave the exact location. It was clearly beginning to curve northward and again it was headed towards a large naval concentration. I immediately contacted the fleet weather central on Saipan. They replied, "We don't believe you." I repeated the observational facts. They still didn't believe but said they would watch. I found out later that when the Navy aerologists finally decided I was right and contacted the Admiral with the information that the fleet and the typhoon would rendezvous in a few hours, he replied, "I don't believe any aerologist. Maintain present course." They rendezvoused with the typhoon. Four destroyers were lost along with 250 aircraft, 1700 men and half a cruiser. You may have read a novel about that storm. It was called "The Caine Mutiny." It really happened—due to anti-intellectualism, misinformation, and in my opinion a large dose of stupidity.

Years later Prof. John Thomson, a past president of this Academy, Prof. Robert Ragotzkie, Dr. James Larsen and I camped with a group of Eskimos, called the Utkusiksalingmiut, at the mouth of the Back River in Arctic Canada. We noticed that the forty Eskimos included only four able-bodied adult male hunters and no teenagers who could replace the hunters if they were lost. One dead hunter would represent a 25% reduction in food supply. When we got back to Baker Lake, we reported this to the Department of Northern Affairs people who were responsible for the welfare of the Eskimos. They said they had not visited the Utkusiksalingmiut, but that they would.

We flew over the Eskimo camp each year or so for the next few years and counted the people. The forty dwindled to seventeen, then eleven, then none. Later I saw these same officials and asked if they had visited that group of Eskimos. They answered, "No, but we intend to." Too late. They were gone, presumably by starvation.

With solid information available, with simple rational analysis, with fairly obvious consequences predictable, why do important events still come as disasters which could have been avoided?

The Wisconsin Academy of Sciences, Arts, and Letters was chartered in 1870 to promote Sciences, Arts, and Letters in the State of Wisconsin. Sciences, Arts, and Letters have flourished in the century since, so much so that constant learning is now necessary to keep up with the "explosion" of knowledge, of books, and of art. How many of the issues that face us today, both in the state and in the world, were even discussed when most of us were in school? If we are to make rational assessments of the issues we must have the background of knowledge and the analytical skills which are necessary. If we are to choose between the variety of predictions of the future in order to plot our own course, we must each have our own internal "nonsense detector." If we are to know who we are and where we came from we must *understand* our heritage and what our artists and writers are saying. If we are to comprehend the world around us, we must understand science as well. If we are to face the future with wisdom, we must combine all these in a rational assessment.

The challenge to the Wisconsin Academy of Sciences, Arts, and Letters is greater than it was in 1870. Let us mobilize our efforts to maintain the Wisconsin tradition of an enlightened citizenry as we face a future of rapid change, in a crowded world full of unknowns. With knowledge we can reduce the uncertainty and make Wisconsin an even better place to live.

FACTORS AFFECTING WATERFOWL USE AND PRODUCTION ON MAN-MADE FLOWAGES IN CENTRAL WISCONSIN

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Abstract

Factors affecting waterfowl use and production on 3 man-made flowages (B Flowage, D Flowage, MV Flowage) in central Wisconsin were studied from April 1975—August 1976. Production of ducklings on the 3 flowages combined was 3-8 times lower than reported from natural wetlands in southern Wisconsin. This overall low production was directly related to poor soil and water fertility. Flowage soils were acidic; water was very soft, and both were low in nutrient content. Poor fertility resulted in low invertebrate populations that, on 2 flowages, were largely unavailable to puddle ducks during the breeding and brood-rearing periods. However, waterfowl use days on B Flowage were 6 times that of D Flowage and 12 times the use on MV Flowage. Further, duckling production on B Flowage was 25-32 and 4-5 times that of D and MV Flowage, respectively. Soil and water fertility were not substantially greater on B than on D and MV Flowages, but plant and invertebrate foods were of better quality and more available due to shallower water levels. Puddle duck production and use of flowages in nutrient-poor regions can be increased through manipulation of water levels to increase availability of potentially limiting food supplies to spring migrants, breeding puddle duck hens, and developing ducklings.

INTRODUCTION

Waterfowl habitat in Wisconsin has diminished greatly. Jahn and Hunt (1964) reported destruction of approximately one-half of Wisconsin's original 2,025,000 ha of wetlands. Bennett (1977) estimated a 3% annual drainage rate of privately owned wetlands in 13 southeastern Wisconsin counties while Wheeler and March (1979) reported a 9% loss in wetland acreage during a 3-year study in southeastern Wisconsin.

This habitat loss emphasizes the need for protection and management of remaining wetlands if present population levels and recreational uses of Wisconsin's waterfowl resources are to continue. The Wisconsin Department of Natural Resources (WDNR) owns an estimated 108,540 ha of wetlands (King 1971) with an acquisition goal of an additional 72,495 ha at an estimated cost of $10.5 million (Tyler and Helland 1969). However, March *et al.* (1973) stressed that an investment of this magnitude necessitates knowledge of current and potential waterfowl production and use of existing wetlands. They also stated that increased development and management of state-owned wetlands could increase Wisconsin's duck production by 50%.

Management of man-made impoundments should proceed only after data regarding waterfowl use and production potential have been collected. This study investigated factors affecting waterfowl use and production on 3 man-made impoundments on state-owned wildlife management units in central Wisconsin. Although these units are within a low density production region (Jahn and

Hunt 1964), the factors depressing waterfowl use and production had not been studied intensively. Objectives were (1) to determine waterfowl use, density, composition and production; and (2) to examine soil and water quality, emergent and submergent vegetation, and invertebrate populations.

The study was financed by the WDNR through the Federal Aid in Wildlife Restoration Program. R. Hunt, J. Beule and W. Wheeler (WDNR) contributed suggestions and demonstrations of field techniques. J. Haug (WDNR) provided vehicles, equipment and helpful comments during field work. E. Nelson assisted in all phases of the field work. N. Payne (University of Wisconsin-Stevens Point), R. Owen (University of Maine) and E. G. Bolen (Texas Tech University) reviewed the manuscript.

Study Areas

Two of the study areas (B Flowage and D Flowage) are located on the Sandhill Wildlife Area which is situated in southwestern Wood County, 1.6 km west of Babcock, Wisconsin (Fig. 1). These flowages are located in T2IN, R3E, sections 9 and 10 of Remington Township, Wood County, Wisconsin. B Flowage is a Type IV wetland (Shaw and Fredine 1956), 13 ha in size, and mostly covered by emergent vegetation. D Flowage is a Type V wetland, 37 ha in size, 29 ha of which are open water. The two flowages are connected by a narrow drainage ditch while both are surrounded by upland vegetation, mainly oaks (*Quercus* spp.), aspen (*Populus tremuloides*), and jack pine (*Pinus banksiana*).

The third study area (MV Flowage) is located on the Meadow Valley Wildlife Area which is situated about 9.7 km southwest of the Sandhill Area (Fig. 1). This flowage forms the western boundary of the Meadow Valley Flowage and is located in T20N, R3E, sections 9 and 10 of Kingston Township, Juneau County, Wisconsin. MV Flowage is a Type IV wetland, 53 ha in size, and characterized by emergent vegetation interrupted by several small, shrub-covered islands. The flowage is bordered on the north, east, and west by similar impoundments and to the south by oak-aspen hardwoods.

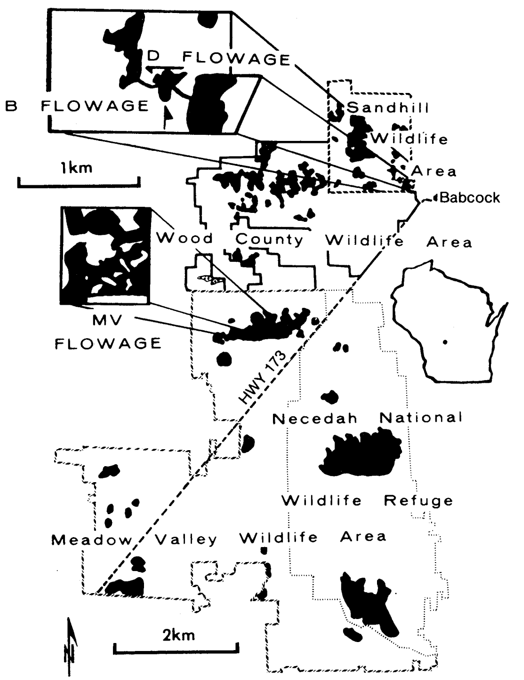

Fig. 1. Location of study flowages showing other wetlands in the area on the state and federal wildlife management units in central Wisconsin.

Methods

Waterfowl Use and Production Estimates

Waterfowl populations were censused between 0430-1300 CST 20 April-8 August 1975 at 7-8 day intervals and from 1 April-24 May 1976 at 2-3 day intervals. Census results were tabulated as use days per species per flowage (1 use day = 1 duck/day/flowage). Breeding pair populations were determined as outlined by Dzubin (1969). Waterfowl nests were located by searching available cover on and within 60 m of each impoundment. Searches were conducted once from 15-21 May 1975 and 2-3 times from

25 April-16 June 1976. Periods of nest initiation were calculated by backdating broods.

Duck broods were censused from tree platforms using a 20-60X spotting scope. Each flowage was censused at least once every 2 weeks from 2 June-23 July 1976, with counts conducted 0.5 hrs before to 1.5 hrs after sunrise or sunset. Brood species was recorded and age class determined (Gollop and Marshall 1954). Duck production represents the number of young/brood to reach age class IIa (18-22 days) or older. A production range was calculated distinguishing resident and transient broods using each flowage. The minimum estimate counted only broods observed 2 or more times on a flowage (residents), whereas the maximum estimate included broods observed only once (transients).

Habitat Analysis (Soil, Water, Vegetation and Invertebrates)

Soil samples were collected from B and D Flowages (4 and 3 sample sites, respectively) on 12 August 1975 and from MV Flowage (5 sample sites) on 30 July 1975. Sample sites were located randomly to provide an even area coverage of each flowage. A core sampler designed by research personnel at the Horicon Marsh Headquarters (WDNR) was used to collect 2 cores/site. The top 7.6 cm from all cores on an individual flowage constituted a composite sample which was frozen until analyzed by the Department of Soil Science, University of Wisconsin-Madison.

Water samples were collected at 2-week intervals, 13 June-15 August 1975 and 31 March-4 August 1976. Samples were taken from surface waters at a station located in the middle and outflow of B Flowage, inflow and middle of D Flowage and the SE, NE, SW, and NW areas of MV Flowage.

Temperature and apparent color were measured in situ using a Hach water analysis kit. Alkalinity, conductivity, turbidity, dissolved oxygen and carbon dioxide were measured at the water analysis laboratory of the Environmental Task Force, University of Wisconsin-Stevens Point (American Public Health Association 1976). Water levels were recorded at 2-7 day intervals at outflow control structures on each flowage.

Emergent vegetation was measured in August 1976 using a series of sample quadrats located within the major vegetative stands on each flowage. Quadrats were 0.25 m^2 and located randomly on transects in the central portion of each stand. Sample size/stand varied dependent on the size of each stand. Parameters measured were (1) number of stems of each species, (2) percent area coverage of each species, and (3) percent area coverage by all species. An importance value (relative density + relative frequency + relative abundance) was calculated for each species within a stand (Cox 1967).

Techniques used to sample submergent vegetation followed Jessen and Lound (1962). Samples were collected from open water areas only and an importance value (relative frequency + relative abundance) was calculated (Cox 1967).

Invertebrates were collected from B Flowage at 2-week intervals, 1 April-8 July 1976 and from D and MV Flowages at 4-week intervals, 15 April-8 July 1976. Sample sites were located randomly in emergent vegetation to provide an even area coverage of each flowage. Samples were taken from the water column (surface samples) and the substrate (bottom samples). At each surface sample site (6 each on B and D Flowages, 9 on MV Flowage) a bottom sample was also taken. Two additional bottom samples were taken on D Flowage and 1 on MV Flowage. Surface samples were taken using a dip net with an area opening of 725 cm^2 and 9 mesh openings/cm^2. Each sample consisted of 4 1-m long sweeps at a depth of 20 cm (0.29 m^3/sample). Bottom samples were collected with a 15.2 cm^2 Ekman grab with 1 grab taken/site (0.02 m^2/sample).

TABLE 1. Waterfowl use days and use days/ha on study flowages in central Wisconsin, 1 April-24 May 1976.[a]

Species	B Flowage 13 ha	D Flowage 37 ha	MV Flowage 53 ha	Total 103 ha	% total
Mallard	111 (8.5)	128 (3.5)	243 (4.6)	482 (4.7)	8.3
Blue-winged teal	60 (4.6)	108 (2.9)	122 (2.3)	290 (2.8)	5.0
Ring-necked duck	2897 (222.8)	199 (5.4)	404 (7.6)	3500 (34.0)	60.4
Lesser scaup	0 (0.0)	367 (9.9)	11 (0.2)	378 (3.7)	6.5
Canada goose	11 (0.8)	346 (9.4)	245 (4.6)	602 (5.8)	10.4
Other (10 species)[b]	160 (12.3)	305 (8.2)	74 (1.4)	539 (5.2)	9.3

[a] Number in parenthesis is use days/ha.

[b] Green-winged teal (*Anas crecca*), American widgeon (*A. americana*), Shoveler (*A. clypeata*), Wood duck (*Aix sponsa*), Canvasback (*Aythya valisineria*), Common goldeneye (*Bucephala clangula*), Bufflehead (*B. albeola*), American merganser (*Mergus merganser*), Red-breasted merganser (*M. serrator*), Hooded merganser (*M. cucullatus*).

Samples were hand-sorted and invertebrates preserved in 70% isopropyl alcohol. Numbers in each taxon were tabulated and volume determined (Myers and Peterka 1974).

RESULTS AND DISCUSSION

Waterfowl Use and Production Estimates

There were 5791 waterfowl use days (56/ha) on study flowages in 1976, with B Flowage receiving more use than D or MV Flowage (Table 1). Total use days/ha on B Flowage (249) were 6 × D Flowage and 12 × MV Flowage. The ring-necked duck (*Aythya collaris*) comprised 89% of all use on B Flowage while other diving ducks, particularly lesser scaup (*A. affinis*) used D Flowage extensively. Breeding puddle duck (mallard, blue-winged teal) use days/ha was 13.2 on B Flowage versus 6.4 and 6.9 on D and MV Flowages, respectively.

Ring-necked duck use of B Flowage resulted from an abundant food supply. Mendall (1958) reported spring foods of ring-necked ducks in Maine as 89% vegetative matter with burreeds (*Sparganium* spp.) and pondweeds (*Potamogeton* spp.) comprising 31%. These plants were dominant on B Flowage. In contrast, D Flowage lacked vegetation in open water areas and water levels along the shoreline were too shallow to permit feeding by diving ducks.

Lesser scaup use of D Flowage occurred because of deeper water (Fig. 2) and the

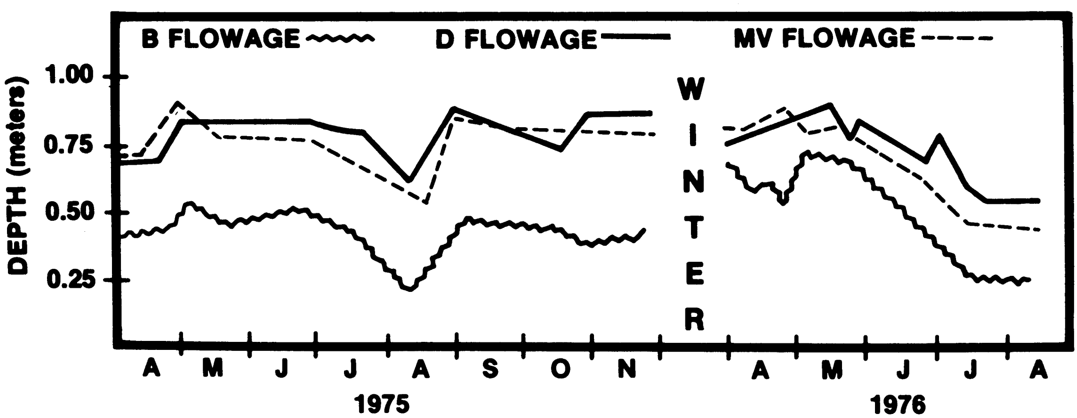

Fig. 2. The water level fluctuations on study flowages in central Wisconsin, 1975 and 1976.

presence of an invertebrate food supply. Bellrose (1976) reported that lesser scaup feed mostly on animal matter and in deeper water than other diving ducks except sea ducks. Invertebrate samples collected on D Flowage contained large leeches (Hirudinea) which were nearly absent from B and MV Flowages. Leeches constitute an important food of lesser scaup (Dirschl 1969, Bartonek and Murdy 1970).

Puddle duck use on all flowages was restricted to areas of shallow water often characterized by emergent vegetation. Water depths on D Flowage exceeded levels recommended by Linde (1969) (Fig. 2) for puddle ducks. Feeding activity occurred in the narrow band of emergent vegetation along the shoreline but as water levels receded during the season this site became unavailable. In contrast, B Flowage received greater puddle duck use/ha because water was shallower and covered with dense stands of quality food plants, most notably manna grass (*Glyceria borealis*) and rice cut-grass (*Leersia oryzoides*).

Deep water restricted feeding sites available to puddle ducks on MV Flowage. Steep-sided dikes surrounded the flowage and did not provide a gradient where shallow water feeding sites could develop. Shallow water sites used by puddle ducks occurred around islands and at the north end of the flowage where an area of upland vegetation between the dike and water allowed development of a shallow water gradient into the flowage.

Restriction of food availability to breeding puddle duck hens is important, particularly when residual seed sources are present. On all flowages, seeds had accumulated in bottom substrates where deep water often rendered them unavailable to puddle ducks (Baldassarre 1980). Seeds provide a ready source of energy (carbohydrates) needed for daily metabolic activity (Bardwell et al. 1962) while protein obtained from invertebrates is used in egg development (Swanson and Meyer 1973). Restriction of residual seed availability may force hens to catabolize valuable protein sources for energy and thus they may not reproduce efficiently, especially if the invertebrate food supply is limiting.

Breeding pair density for all flowages was 0.08/ha in 1975 and 0.10/ha in 1976. Pair density was similar on each flowage (0.08/ha-0.10/ha) except D Flowage in in 1975 (0.02/ha). This density was 6-20 times lower than reported from natural wetlands in southern Wisconsin (Jahn and Hunt 1964). However, although pair density was low, the number of water areas in this region (Fig. 1) may offset a low per ha density and substantially contribute to the state's breeding pair population.

Nest searching (75 hrs) yielded only 3 nests for the 2 years and all were ultimately destroyed by raccoons (*Procyon lotor*). Mallards initiated nests throughout April with a slight peak (24%) occurring in week 3. Blue-winged teal began 59% of their nests from 19-26 May while wood ducks nested from 14-28 April (80%). Although few nests were located, if nest predation is severe its effect may be compounded

TABLE 2. The production per hectare of age Class II and older ducklings on the study flowages in central Wisconsin, 1976.

Flowage	*Hectares*	*Mallard*	*Blue-winged teal*	*Wood duck*	*Total Production/ha*
B Flowage	13	0.5-1.0	0.5	1.5-1.7	2.5-3.2
D Flowage	37	0	0	0-0.1	0-0.1
MV Flowage	53	0.5	0.1	0	0.6

in nutrient-poor regions as renesting hens may have difficulty obtaining sufficient nutrition.

The production of ducklings on all flowages was 0.56-0.73/ha in 1976 (Table 2). Production was highest on B Flowage (2.5-3.2/ha) and lowest on D Flowage (0.0-0.05/ha). Total production per ha was 3-8 times lower than reported in productive marshes in southern Wisconsin (Jahn and Hunt 1964). Jahn and Hunt (1964) considered 2.5 ducklings/ha as good production on quality natural wetlands in that region. Moyle (1961) estimated waterfowl production from soft water areas in Minnesota as 0.31/ha. Although production was low on a per ha basis, this region may be producing a substantial number of fledged ducklings due to the extensive water acreage in the region (Fig. 1).

Habitat Analysis (Soil, Water, Vegetation and Invertebrates)

The soil of each study flowage was strongly acidic, sandy, high in organic matter content and generally low in nutrients (Table 3). Nutrient level requirements for plants in wetland soils are not established, therefore field crop levels were used for comparison (Spencer 1963). Flowage soil levels of nitrate nitrogen, calcium and potassium were low and phosphorus and magnesium were medium when compared to field crop levels. Nutrient levels were also compared to a high quality production area in Wisconsin (Beule and Janisch 1976), where pH and nutrient levels were generally higher than on study flowages.

TABLE 3. The soil analysis of study flowages in central Wisconsin, July and August 1975.

	B Flowage	*D Flowage*	*MV Flowage*
pH	4.9	5.0	4.9
Phosphorus (mg/1)	73	75	33
Calcium (mg/1)	375	400	375
Potassium (mg/1)	38	25	38
Magnesium (mg/1)	100	75	50
Nitrate nitrogen (mg/1)	1.0	4.0	1.0
Sand (%)	81	66	76
Silt (%)	15	28	19
Clay (%)	4	6	5
Organic matter (%)	17	50	12

The high percent of sand and silt comprising study flowage soils is characteristic of Wisconsin's Central Plain Region and is the basic source limiting the fertility of the flowages. Sand and silt are predominantly quartz (SiO_2), a compound usually chemically inactive and therefore of low nutrient supplying capacity (Buckman and Brady 1969).

The high organic content of flowage soils and the fibric to hemic condition of the material limit available fertility because nutrients are accumulating there. When organic matter exceeds about 4% it may become harmful to shallow aquatic systems (Cook and Powers 1958). High nutrient levels often observed shortly after impoundment flooding result from an initial release of soil soluble nutrients and decomposition of preflood vegetation (Whitman 1973). However, as soil conditions become anerobic, the decomposition rate declines, nutrients accumulate in the organic matter and are unavailable for release back into the system (Whitman 1973).

The strongly acidic soil pH accelerates organic matter build-up because decomposition is slowed under acidic conditions (Phillips 1970). Also, anerobic conditions usually exist in submerged organic matter, and decomposition of marsh sediments is often incomplete (Kadlec 1962). Kadlec (1962) suggested that the colloidal content of soil increases with impoundment age as organic matter accumulates. This increases the exchange capacity of that layer, resulting in a loss of nutrients from the water and their accumulation in the soil. Therefore, the accumulation of the limited nutrients present in study flowage soils is of accelerated concern because of initial low fertility.

Water quality of the study flowages was poor (Table 4). Linde (1969) defined unproductive marsh waters in Wisconsin as having an alkalinity less than 10 mg/1. Mean conductivity (24.9 mhos/cm) is below a "low" described by Hem (1970) while a median pH of 6.5 indicated acidic conditions. There was no difference between

TABLE 4. The mean (± SE) value of the water analysis parameters measured on study flowages in central Wisconsin, combining data from 13 June-15 August 1975 and 31 March-4 August 1976.

	B Flowage (n = 36)	*D Flowage (n = 36)*	*MV Flowage (n = 68)*	*All Flowages (n = 140)*
pH (median)	6.6	6.3	6.7	6.5
Alkalinity (mg/1 $CaCO_3$)	8.7 ± 0.5	6.1 ± 0.6	9.2 ± 0.3	8.3 ± 0.3
Conductivity (mhos/cm)	26.6 ± 1.1	21.9 ± 0.8	25.5 ± 0.6	24.9 ± 0.5
Apparent color	145 ± 5	175 ± 8	145 ± 7	153 ± 5
Turbidity (JTU)	1.8 ± 0.2	1.7 ± 0.1	2.2 ± 0.1	2.0 ± 0.1
Dissolved CO_2 (mg/1)	6.1 ± 0.8	6.8 ± 0.6	5.0 ± 0.4	5.7 ± 0.3
Dissolved O_2 (mg/1)	7.0 ± 0.3	7.6 ± 0.3	7.1 ± 0.2	7.2 ± 0.2
Temperature (centigrade)	20.0 ± 1.1	20.2 ± 1.1	19.5 ± 0.8	19.8 ± 0.6

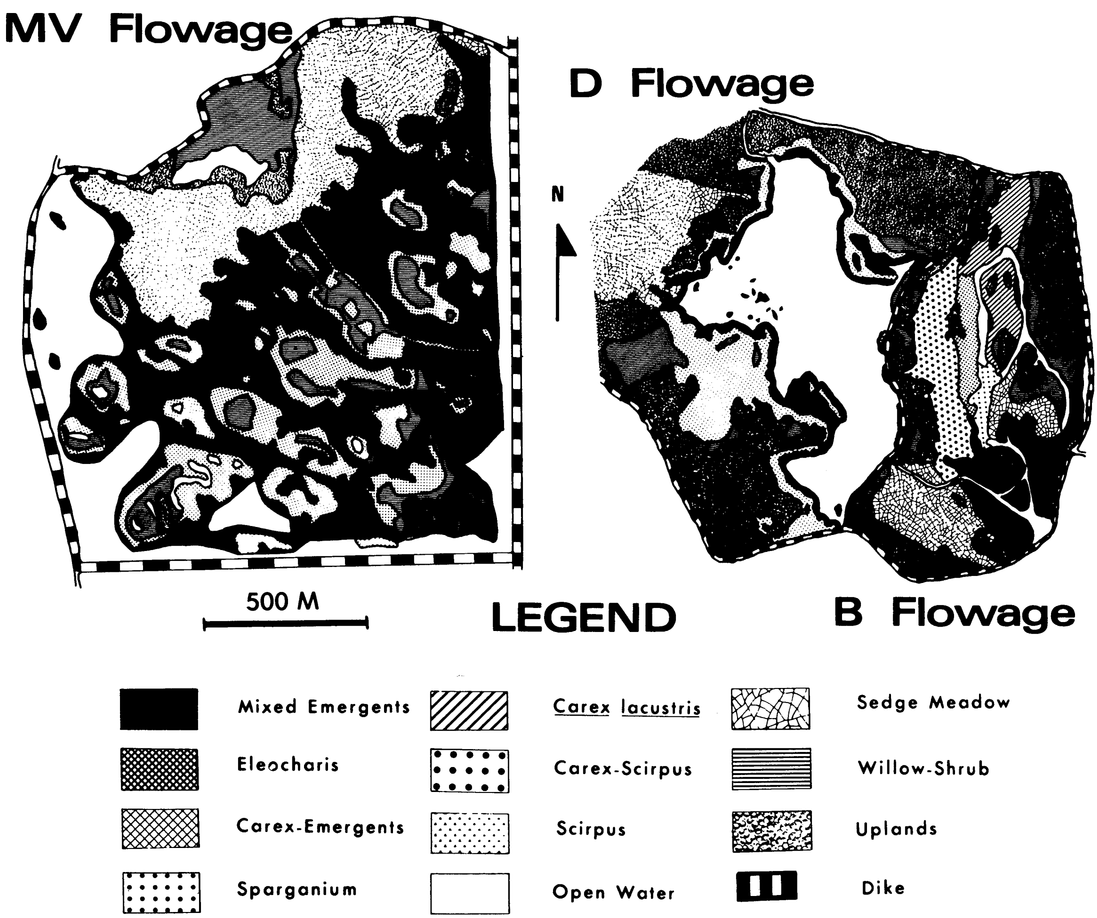

Fig. 3. The vegetative cover type maps of the study flowages in central Wisconsin, 1976.

flowages (P > 0.05) in mean temperature, dissolved oxygen or carbon dioxide, but a difference (P < 0.05) occurred in mean alkalinity, conductivity, turbidity, color and pH.

Of the major vegetative cover types identified on each study flowage (Fig. 3), only 4 (mixed emergents, Carex-emergents, Eleocharis, Sparganium) were used by feeding waterfowl. Rice cut-grass, a valuable component of the mixed emergents type, and the Sparganium type provided a quality food source on B Flowage (Bellrose 1941, Bellrose and Anderson 1943, Coulter 1955). The Carex-emergents type on MV Flowage covered 10.1 ha, but was not used extensively by puddle ducks, perhaps because *Carex* spp. common in waterfowl marshes do not retain quantities of seed through winter (Coulter 1955). Also, only 0.8% of all seeds collected from 40 bottom invertebrate samples on MV Flowage in 1976 were *Carex* spp. seeds. Stem density for each stand and the major species present are summarized by Baldassarre (1978).

The submergent vegetation of B Flowage was dominated by pondweeds (*Potamogeton* spp.), normally a valuable waterfowl food (Martin and Uhler 1939). Vegetative coverage/sample was 16% but the shallow water may have offset low abundance by increasing food availability, particularly to puddle ducks. In contrast, the submergent community on D Flowage contained little vegetation (4% coverage/sample), thus not producing an abundance of waterfowl food. Also, the deep water almost completely eliminated food availability to puddle ducks which restricted feeding activity to the shallow water band of emergents along the flowage's perimeter.

Submergent vegetation on MV Flowage contained large amounts of vegetation (56% coverage/sample) dominated by pondweeds and waterweed (*Elodea canadensis*). However, waterweed is a low value duck food (Martin et al. 1951) whereas the pondweeds were relatively unavailable to puddle ducks because of deep water.

Invertebrate Populations

The high volume of Chironomidae and Mollusca (78% Gastropoda) in the surface samples on B Flowage (Fig. 4) attracted breeding puddle ducks and duck broods. Many investigators found Mollusca (mainly Gastropoda) and Chironomidae to be important foods of breeding puddle ducks and young ducklings (Krapu 1974, Swanson et al. 1974). Krapu and Swanson (1975) found these taxa to be rich sources of protein and calcium, while Swanson and Meyer (1973) reported that Chronomidae, along

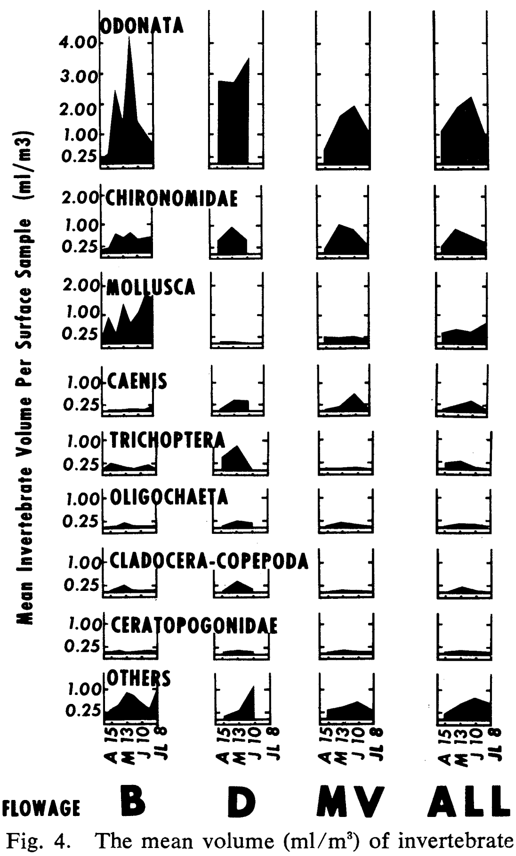

Fig. 4. The mean volume (ml/m³) of invertebrate taxa collected from the surface samples on B Flowage (n = 6), D Flowage (n = 6), MV Flowage (n = 9) and All Flowages combined (n = 21) in central Wisconsin, 1 April-8 July 1976.

with Corixidae and Gammaridae, provided the most complete range of amino acids based on the requirements of young ducklings. Sugden (1973) stated that the high quality protein provided by Chironomidae larvae is important in the diets of most if not all young ducks.

The shallow water on B Flowage increased the availability of invertebrates, particularly bottom fauna. Sphaeriidae, Chironomidae and other taxa were more abundant than on D or MV Flowages (Fig. 5). The greater abundance and more available taxa in bottom samples on B Flowage may have been the most important factor in attracting broods to this flowage. Swanson and Meyer (1973) stressed the importance of shallow water in increasing invertebrate availability to feeding puddle ducks. High invertebrate populations on B Flowage resulted from the interspersion of shallow water with dense emergent vegetation. Voigts (1976) found high invertebrate populations in areas of open water interspersed with emergents. Schroeder (1972) recorded greatest invertebrate abundance in shallow "feather edge" areas of emergents.

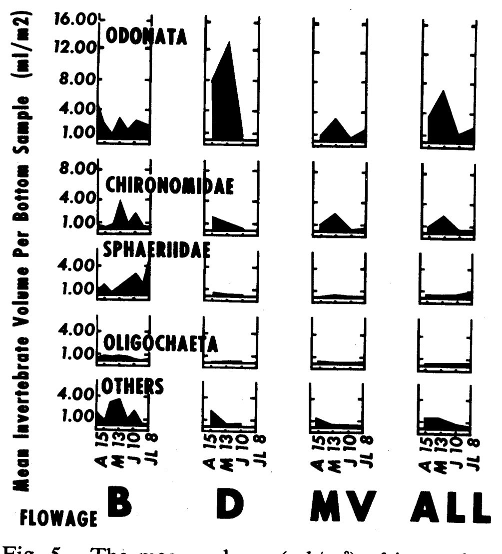

Fig. 5. The mean volume (ml/m²) of invertebrate taxa collected from the bottom samples on B Flowage (n = 6), D Flowage (n = 6), MV Flowage (n = 10) and All Flowages combined (n = 22) in central Wisconsin, 1 April-8 July 1976.

Periodic drying and flooding of emergent vegetation also increased invertebrate abundance on B Flowage because much of the vegetation was exposed as water levels receded through summer but was reflooded in spring. These fluctuations also caused the high surface invertebrate populations on D Flowage as all sites were located in shoreline emergents subjected to water fluctuation. Swanson et al. (1974) stated that high invertebrate populations occur when spring runoff water inundates dead vegetation from the previous year. This creates a "hay infusion" which promotes high invertebrate biomass due to the rapid breakdown and utilization of stored organic matter.

The deep open water area on D Flowage characterized by sparse submergent vegetation contained few free-swimming invertebrates. Invertebrate populations on MV Flowage were subjected to these same environmental influences (water fluctuation and substrate); however, population abundance was limited by steep-sided dikes which restricted water fluctuation and invertebrate availability.

Water level fluctuations also were important in determining invertebrate availability. For example, during the 4th week of May 1976 the flowage immediately north of MV Flowage was subjected to complete drawdown. The drawdown greatly increased duck and waterbird use because shallow water increased food availability (Baldassarre 1980). Swanson and Meyer (1977) found that receding water levels create a short term increase in invertebrate availability due to shallow water and concentration of organisms within a reduced water volume. The increase of food availability in nutrient-poor aquatic ecosystems may be of compounded importance to breeding puddle ducks as increased availability may somewhat offset the low food abundance as compared to a more fertile marsh.

The comparatively low invertebrate biomass on study flowages is probably the single most important factor limiting waterfowl production. Krull (1976) reported a mean volume of invertebrates collected from bottom samples in New York marshes as 2-4 times the mean volume of All Flowages and up to 9 times that of any individual flowage. The bottom invertebrate populations on Type 4 wetlands in Wisconsin's Horicon Marsh region (Wheeler and March 1979) were 13-38 times that on all flowages while surface sample volumes averaged 4-10 times greater.

Management Recommendations

The poor flowage fertility will always limit invertebrate abundance; therefore, management should be directed toward increasing invertebrate and plant food availability. During the puddle duck breeding season flowage water levels should be <30 cm, thus increasing food availability.

Selected flowages could be drawn-down during the peak spring migration periods, thus creating a highly available food supply which may attract additional breeding pairs to the area. Higher water levels should be maintained in some flowages to insure a water supply throughout the brood rearing season.

Also, to stimulate soil and water fertility, each flowage should undergo a complete drawdown on a 5-7 year rotational basis (Whitman 1976). The first drawdown should span 2 growing seasons to maximize the decomposition of the heavy organic matter accumulation.

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AGE, GROWTH AND TOTAL MORTALITY OF RAINBOW SMELT IN WESTERN LAKE SUPERIOR[1]

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Abstract

Age and growth were determined for 962 rainbow smelt, *Osmerus mordax* (Mitchill), captured from western Lake Superior in 1976 and 1977. The body-scale relationship, based on total length (mm, L) and scale radius (mm, S) was $L = 74.3S + 1.2$. Smelt attained average lengths of 64, 126, 162, 184 and 203 mm at ages 1 through 5 respectively. The length-weight relationship based on total length (mm, L) and weight (g, W) was $\log_{10}W = 3.01 \log_{10}L - 5.351$. Back-calculated mean length at age was greater for females than males at ages 3-5. Mortality rate was estimated from a sample of 3050 smelt captured from western Lake Superior between 1973 and 1977. The overall annual total mortality rate was estimated at 57%. Mortality was 40% during the fourth growing season and 69% during the fifth growing season. The mortality rate of males was higher than females as reflected in a sex ratio for mature smelt of 2.37 females per male. Warmer temperature and high food availability in the Superior-Duluth harbor resulted in faster growth of young-of-the-year smelt than in the lake proper.

INTRODUCTION

Rainbow smelt (*Osmerus mordax*) support an important commercial fishery in Lake Superior. Commercial harvest of smelt began in 1952 with a catch of 20 metric tons and rose at a rate of approximately 40% per year until 1963 when production stabilized at about 635 metric tons annually (Baldwin and Saalfeld 1962, plus 1970 supplement). By 1975 smelt accounted for 20% by weight of the total commercial catch from Lake Superior. Eighty-nine percent of the total smelt catch is taken from the western end of the lake (Wisconsin and Minnesota waters). The sport fishery for smelt is also significant as evidenced by the thousands of fishermen who travel to the shores of Lake Superior each spring to catch smelt by seine and dip net during the spawning runs. Smelt are also the primary forage for lake trout (*Salvelinus namaycush*) and other salmonids in Lake Superior where alewives (*Alosa pseudoharengus*) have not become as well established as in the lower Great Lakes (Anderson and Smith 1971).

The purpose of this study was to determine mortality and current growth of rainbow smelt in western Lake Superior for use

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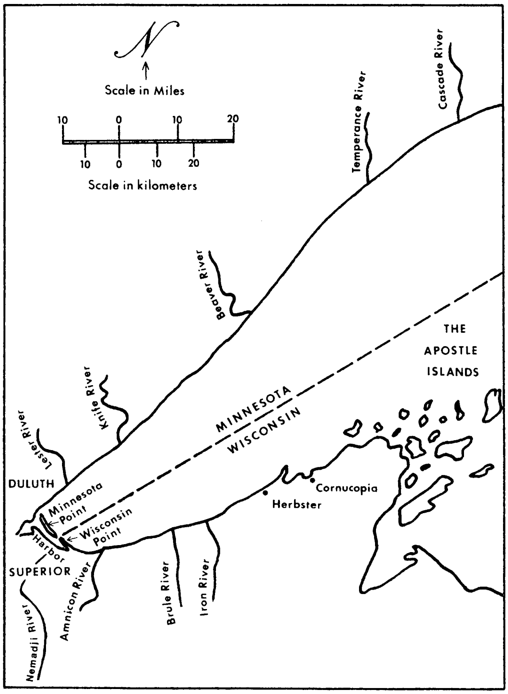

Fig. 1. Study site for the western Lake Superior research.

in continuing studies to determine the role of smelt in the overall ecology of the lake. Growth and abundance of Age 0 rainbow smelt in the open lake and the Superior-Duluth harbor was compared to determine the significance of the harbor as a nursery area.

Growth of smelt in western Lake Superior was estimated by Hale (1960) and Bailey (1964) but mortality estimates have not been presented by these or other authors. In-season growth of young-of-the-year smelt in Lake Superior has not previously been estimated nor has any comparison been made between growth of young smelt in the harbor and in the lake proper.

Methods

Age and Growth

Samples were collected during April-August 1976, 1977 from Superior, Wisconsin to the Beaver River on the north shore and from Superior to the Brule River on the south shore (Fig. 1) at depths of 1 to 40 meters. A total of 611 fish were captured with seines and dip nets during the 1977 spawning season from the following locations: Beaver River (115 fish); Knife River (92 fish); Wisconsin Point (158 fish); Amnicon River (126 fish) and the Brule River (120 fish). Non-spawning fish (351) were captured with semiballoon bottom trawls having 7.6 and 9.5 m headropes. The small net was constructed from 12.7 mm bar mesh with a 6.4 mm cod end liner. Of the 351 non-spawning fish, 322 were captured in the summer of 1976 and 29 in the summer of 1977.

To reduce sampling bias due to strong year classes or smelt segregation by age and size, the subsample of fish to be aged was selected to include adequate numbers of fish at all size intervals between 52 and 242 mm. After preservation in 10% formalin, individual specimens were weighed to the nearest tenth of a gram and measured for total length to the nearest millimeter. Several scales were removed from the right side between the dorsal fin and the lateral line. Scale measurements for age were made under either a light microscope or scale projector, and standardized to mm.

Back-calculations of length at age were based on a linear body-scale relationship. Separate body-scale relationships were estimated for both sexes and a combined sample which included some specimens of indeterminate gender.

The length-weight relationship and the coefficient of condition were estimated. Total length to standard length conversion factors were calculated to allow comparison of the results from this and other studies. The conversion factor was 0.861.

Young-of-the-Year Growth

Using a .571 mm mesh one meter diameter net, age 0 rainbow smelt were collected weekly between 19 May and 18 August 1977. Samples were taken day and night near the surface (0-4 m) over areas 9 m deep east of the mouth of the Nemadji River in the harbor and off Wisconsin and Minnesota points in the lake proper (Fig. 1). A total of 113 samples containing an estimated 22,000 smelt larvae was obtained. A random subsample of up to 100 young-of-the-year rainbow smelt was obtained from each haul and the individual specimens weighed and measured. A total of 2,912 specimens were examined during the sample period.

Mortality

Because smelt segregate by age and show major variations in year class strength as well as seasonal shifts in spatial distribution (MacCallum and Regier 1970; McKenzie 1958, 1964) estimation of mortality is complicated. Mortality of the combined sexes was estimated from postspawning samples collected with 7.6 and 9.5 m trawls near Wisconsin and Minnesota points during May and June, 1973-1977, in water less than 16 m deep. Average mortality for the individual sexes was estimated using 13 trawl samples taken during May and June 1977 from water less than 16 m deep. Random samples from these catches were used with stratified aged samples to estimate population age structure (Ricker 1975). The stratified aged samples were composed of 803 fish captured in 1976 and 1977, including spawners, and were applied to years 1973-1977 under the assumption that growth rate did not change significantly in that time or within those year classes. Catch curves, percentage survival and mortality were estimated from population structure (Ricker 1975). Average annual total mortality rate (A), annual survival rate (S) and instantaneous mortality rate (Z) were estimated using linear regres-

TABLE 1. Average total length (mm), weight (g) and condition of rainbow smelt in western Lake Superior, 1976-77.

		Statistics at Capture								Back-Calculated Lengths at Age				
Sex	*Age Class*	*n*	*Length*	s	*Weight*	*s*	*K*[a]	*s*	*1*	*2*	*3*	*4*	*5*
Males[b]	2	54	141	8.5	15.9	3.5	.559	.048		145			
	3	139	164	13.6	26.3	6.9	.582	.047		125	164		
	4	74	179	12.3	34.1	8.0	.585	.044		121	157	176	
	5	8	186	10.3	35.2	8.1	.539	.058		99	141	172	184
Weighted mean										127	161	176	184
Females[b]	2	87	141	12.0	15.9	4.6	.553	.065		144			
	3	162	168	16.8	27.6	8.3	.570	.063		128	169		
	4	104	188	14.2	38.5	9.4	.572	.061		122	164	190	
	5	27	205	15.6	47.9	10.5	.551	.058		112	151	179	204
Weighted mean										129	166	188	204
Total Sample	1	106	101	17.4	6.3	3.1	.556	.069	90				
	2	263	137	14.1	15.1	4.9	.567	.062	69	137			
	3	357	166	15.3	72.1	7.6	.575	.057	57	123	165		
	4	193	186	14.9	37.5	9.3	.575	.055	56	118	160	185	
	5	43	204	17.0	47.2	11.6	.547	.061	55	110	152	181	203
Weighted mean									64	126	162	184	203

[a] K is coefficient of condition computed as: $K = W \times 10^5/L^3$, where W is weight in g and L is total length in mm.

[b] Because of the difficulty in determining sex of immature smelt, the body-scale relationships of males and females were based on models which contained no age one fish and therefore were not used to back-calculate lengths at age one.

sion on the descending limbs of the catch curves (ages 3 to 5). Estimates for specific ages (3 to 4 and 4 to 5) were made using percentage survival from the equation $S = (N_{t+1})/N_t = 1 - A = e^{-Z}$.

Results

Age and Growth

The linear body-scale relationships are defined by:

males	$L = 67.3S + 20.1$	$r^2 = 0.87$
females	$L = 70.8S + 8.8$	$r^2 = 0.87$
total	$L = 74.3S + 1.2$	$r^2 = 0.97$

Average lengths at each annulus were back-calculated for males, females and all fish (Table 1). At each age males were smaller than females. Rate of growth in length (total sample) was fastest during the first (64 mm) and second (62 mm) growing seasons. Later length increments decreased with age.

Weight increments were greatest between ages 2 and 3. At ages 3, 4, and 5 females in the sample were heavier than males. The coefficient of condition for males was higher than females at ages 2, 3 and 4 (Table 1). For both males and females the highest condition coefficient occurred at age 4.

The length-weight relationships are described by the following formulae:

males
$$\log_{10}W = (3.1340) \log_{10}L - 5.5368$$
females
$$\log_{10}W = (3.0021) \log_{10}L - 5.2550$$
total
$$\log_{10}W = (3.0477) \log_{10}L - 5.3510$$

Growth estimates from this study were similar to those for Lake Huron (Baldwin 1950) but slower than that reported for Lake Michigan (Robinson 1973) and the Parker River (Murawski and Cole 1978).

Young-of-the-Year Growth

Average total lengths of Age 0 smelt collected from the harbor and the lake show the harbor accommodated faster growth (Figure 2). Length of Age 0 rainbow smelt in the harbor was defined by the equation $L = 0.231T + 7.738$ with $r^2 = 0.90$ where L = total length in millimeters and T = time in days from May 18, 1977. May 18 was selected as the average date of smelt hatch in western Lake Superior on the basis of spawning and incubation periods. Length of Age 0 rainbow smelt in the lake was described by the equation $L = 0.118t + 6.884$ ($r^2 = 0.69$). Comparison of the two regression lines (Fig. 2) showed that growth in length was significantly faster in the harbor (Neter and Wasserman 1974; $F_{2,19} = 21.43$; $p < .001$).

For the harbor the estimated relationship between average Age 0 smelt weight and time was $W = .0539\ T^{2.23}$ with $r^2 = 0.97$ while the corresponding relationship for the lake was $W = .0501\ T^{1.95}$ with $r^2 = 0.67$ where

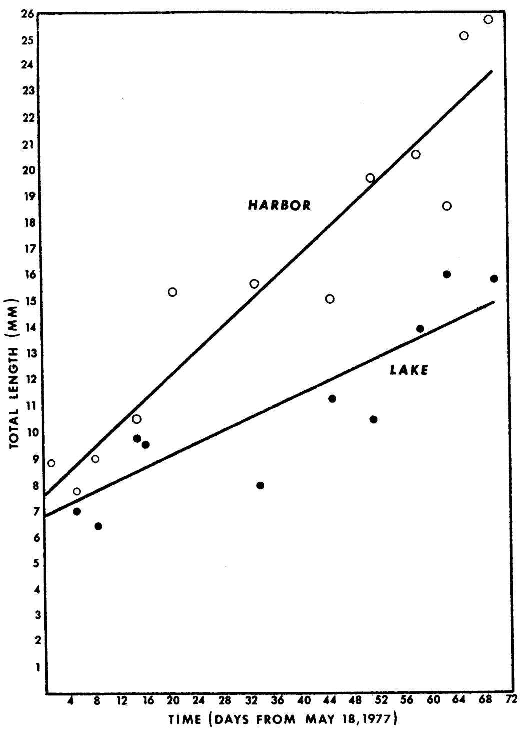

Fig. 2. Comparison of growth in total length of larval smelt in the harbor and in the lake proper.

W = weight in grams × 10^4 and T = time in days from May 18, 1977. After the tenth day, Age 0 smelt in the harbor weighed at least twice as much as those growing in the lake. The rate of growth in weight was significantly faster in the harbor than in the lake proper ($F_{2,17} = 6.76$, $p < .01$).

Mortality

Calculated age distributions for 1973 to 1977 are given in Table 2 and were used to generate catch curves for males, females and the combined sample. An instantaneous total mortality rate (Z) of 0.847, corresponding to an annual rate (A) of 57% was computed for the sexes combined (Table 2). The annual rate for sexes combined between age 3 and age 4 was 40% and between age 4 and age 5 was 69%. The instantaneous mortality rate for males was 1.463 and for females was 0.545. These values corresponded to annual mortality rates of 77% and 42% for the sexes respectively.

The sex ratio, for all postspawning (May, 1977) lake collections in which random samples of smelt were sexed, was 2.37 females to 1 male. There were significantly fewer males in western Lake Superior than expected under the hypothesis that half the population was male and half female ($p < .001$, $\chi^2 = 77.41$, df = 3).

Discussion

The observation that male mortality rate is greater than female mortality is supported by the low ratio of males to females in the shallow water of the lake during the post-spawning period and by studies on Parker River populations by Murawski and Cole (1978). Higher male mortality may be a result of their higher vulnerability to post-spawning die-offs which occur annually in the area (Schaefer 1979). High male mortality rate may also be a result of the rainbow smelt sport fishery in Lake Superior which exerts its greatest pressure during the early portion of the spawning run which is composed principally of males (Bailey 1964).

Several factors could have contributed to the comparatively rapid growth of larval smelt in the harbor. Warm, nutrient-rich water is introduced into the Superior-Duluth harbor by two major rivers. Although this study did not attempt to quantify production of algae or zooplankton, it was evident that the harbor was more productive than the lake. The concentrating cup of the meter net used to sample larval smelt was often filled with zooplankton during collections from the harbor but never during collections from the lake. Temperature profiles showed that water in the harbor averaged 3° C

TABLE 2. Percent age structure and mortality rate of rainbow smelt in western Lake Superior, 1973-77.

Sample Year	*Sex*	*n*	*1*	*2*[a]	*3*	*4*	*5*+	*S*	*A*	*Z*
			Percent At Age							
1973	Both	710	7.3	38.2	36.7	15.2	2.6	.266	.734	1.324
1974	Both	303	7.8	26.6	33.8	24.8	7.0	.455	.545	.787
1975	Both	86	12.7	45.9	20.5	9.1	11.8	.759	.241	.276
1976	Both	164	7.4	21.5	42.8	22.6	5.7	.365	.635	1.009
1977	Both	1787	4.3	29.5	33.8	22.7	9.7	.536	.464	.624
1977	Male	288		19.5	50.4	27.4	2.7	.231	.769	1.463
1977	Female	683		23.4	36.9	27.3	12.4	.580	.420	.545
1973-77[b]	Both	2800	6.5	31.4	34.8	20.9	6.4	.429	.571	.847

[a] For males in 1977 and females in 1977 the percent at age two includes both age 1 and age 2 fish.
[b] Because of small sample size, the years 1975 and 1976 were not included.

warmer than near shore water in the lake which also may have promoted faster growth.

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WETLAND ANTS: INTERNAL MOUND TEMPERATURE AND HUMIDITY PREFERENCES; LOCATION AND SHAPE OF MOUNDS AS ADAPTATIONS TO A WETLAND ENVIRONMENT

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Abstract

Formica montana, a mound building wetland ant, was studied during the autumn of 1979 in a sedge meadow at Waubesa Wetlands, town of Dunn, southern Dane County, Wisconsin. The report is divided into two parts.

Part I deals with the effects of temperature and humidity on ant activity within the mound nest. By disecting an ant mound with a clear sheet of plexiglass, the activities of the ants could be observed within the mound. Ants were observed stratified in the warmest and most humid parts of the mound nest, even when the temperature levels within the mound were artificially manipulated.

Part II describes the location and shape of the mound. An association between the location of red-osier dogwood (*Cornus stolonifera*) and *Formica montana* mounds was observed. A number of hypotheses are suggested to explain the association. The shapes of different-aged ant mounds suggest that ants first build their mounds up, above the surface of the wetland, and then out, at which time they crop the vegetation that otherwise shades the mound's surface. By constructing mounds in this manner, wetland ants maximize the range of temperatures and humidities available.

Introduction

Formica is a genus of ants noted for distinct methods of nest construction (Creighton, 1950). According to Wheeler (1910), there is much variability in nest architecture, not only within a genus of ants but also within a species. The architectural variability within a species depends on the habitat and the time of year. *Formica montana,* an ant that builds a mound nest, occupies a variety of habitats with peat soils, including prairie remnants, sedge meadows, and forests (Ohio to Colorado) (Francoeur, 1973). These animals and their mounds were studied in a sedge meadow in southern Wisconsin during the cool autumn months, when the ants stayed inactive within their mounds.

Mound building wetland ants find themselves in a curious situation. I know of no other strictly terrestrial burrowing animal that spends its lifetime in peat soil periodically flooded by a fluctuating water table. Mound flooding is not the only hazard: wetland ants are ectothermic and must also contend with unfavorable temperature fluctuations. This study views these problems by considering certain characteristics of the ants' mound. Denning *et al* (1977) studied *Formica cinerea montana* mounds and found that the mounds' properties were similar to those of gravel; thus the mounds' clayey wetland soil drains quickly. More attention has been given to the thermal properties of mounds. According to Raignier (1948) and von Frisch (1974), an earthen mound offers a selection of temperatures and humidities that can change by the hour. In the early and late hours of daylight, the dome shape allows the mound to receive about three times the solar radiation that could be obtained on a flat area of the same radius.

This study is divided into two parts. Part I reports the investigation of ant behavior within the mound, including adjustments to the fluctuating water-table, natural and controlled autumn temperatures, and humidity. Part II is concerned with the relationship between ant mounds and the surrounding vegetation, and proposes a strategy for mound construction by ectothermic terrestrial animals in a wetland environment.

Methodology

Formica montana, identified by A. Francoeur, Université du Quebec a Chicoutimi, was studied during September, October, and November 1979 at a sedge meadow in Waubesa Wetlands, Dane County, southern Wisconsin.

Part I

Eight ant mounds were excavated to examine their basic structure and stratification of ant activity. One mound, hereafter referred to as the test mound, was bisected by a clear plexiglass sheet that extended well below the water table. One half of the bisected mound was packaged in plastic so that it could be removed during periods of observation and then replaced. Seven copper-constantan thermocouples were secured to the vertical midline of the plexiglass, spaced at 10 cm intervals at and below the surface of the mound (see figure 1). Mound temperatures were taken on seven days in October. Millivolts, later converted to degrees Celsius, were recorded with a potentiometer. An electric heating rod, in circuit with a variable transformer, was placed 35 cm below the mound surface and next to the plexiglass in the permanent half of the mound. The percent moisture available to the soil, recorded with a Bouyocous moisture meter (model BN-2N) on four days in October, was measured at five depths on and below the surface of the test mound (see figure 2).

Part II

Height and width of each mound to the nearest dm, fraction (to the nearest third) of the mound top covered by vegetation, and the distance between a mound and the nearest red-osier dogwood (*Cornus stolonifera*) were recorded for each of 122 mounds. A chi-square test was performed to determine

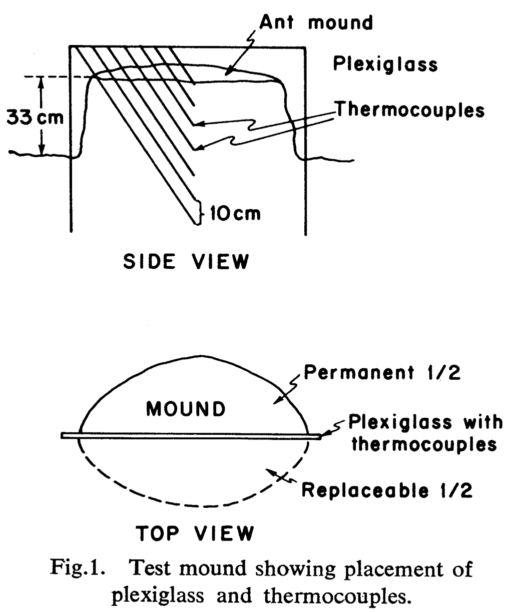

Fig.1. Test mound showing placement of plexiglass and thermocouples.

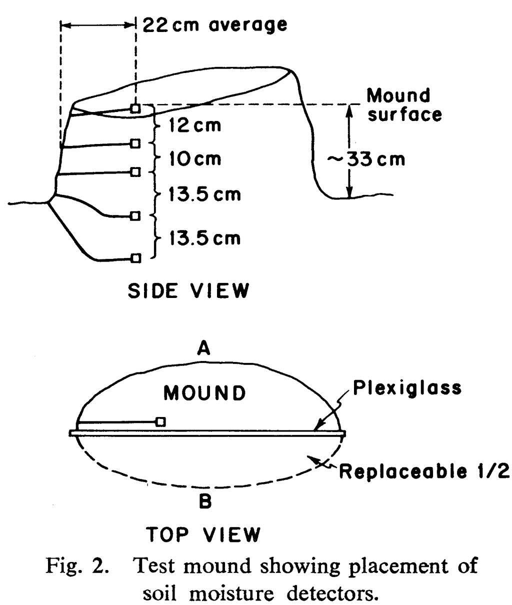

Fig. 2. Test mound showing placement of soil moisture detectors.

whether or not the amount of vegetation covering an ant mound was correlated with the shape of the mound.

Results and Discussion

Part I

Ant Activity Within Their Mounds

Eight excavated ant mounds revealed a network of burrows that extended over 1 m below the wetland surface, more than 65 cm below the lowest recorded water table level. Ants must have been present and active 1 m below the wetland surface when water table levels were lower. Water table levels did drop below 50 cm beneath the wetland surface between 1 April and 30 July 1979 (DeWitt, pers. comm.). Ants were consistently found immediately above the water table in a 2-4 cm horizontal stratum of burrows. These burrows were completely filled with apparently inactive ants. The water table level, measured daily throughout the study period, rose 20 cm. Although appearing completely inactive, the ants were actually active enough to stay just ahead of the rising water. While excavating one of the eight mounds, I discovered a chamber filled with ant pupae. This chamber was unattended and well above the stratified adults. According to Wilson (1970), however, the larvae and pupae are closely attended by adults who move them to areas of preferred temperature and humidity. There are two possible reasons why the pupae were left unattended. First, little development occurs during the cold fall months; chambers at optimal temperatures for pupal development are not available to the ants at this time. Second, *Formica montana* adults are likely to deposit the pupae high in the mound where they will not be flooded by the rising autumn water table.

Temperature Preferences of Ants

Temperatures at the mound-plexiglass interface, level of water to the nearest thermocouple, and location of horizontal strata containing ant activity were recorded on seven days in October (table 1). Because the heating rod was not in place on 13 or 16 October, the highest mound temperatures were at the water table. As expected, the ants clustered in the burrows 5-7 cm above the water table on both these dates. Although the ranges, throughout the entire test mound, of temperatures on 13 and 16 October were only 1.7°C and 2.6°C respectively, the ants were found at the highest constant temperature, that of the water table and peat directly above it. The mound surface temperature fluctuated widely owing to highly variable external weather.

The ants moved from the burrows adjacent to the water table to the preferable

Table 1. Temperatures recorded in 7 different strata within test mound.

Date on which thermocouple temperatures (°C) were recorded	*Thermocouples distances (cm) below test mound surface* 0	10	20	30	40	50	60	*heating rod*	*air temp.*
13 Oct.	9.1	10.6	9.8	10.4	10.75	10.75	10.75$_w$[a]	—	9.25
16 Oct.	13.3	9.5	9.8	10.0	9.3	10.5	10.75$_w$[a]	—	13.0
18 Oct.[b]	15.1	10.3	10.8	10.8[a]	12.6[a]	10.4[a]	10.25$_w$	37.5	—
20 Oct.	22.0[a]	18.75[a]	16.5[a]	16.75[a]	14.5	10.75$_w$	10.5	44.25	—
23 Oct.	5.25	9.5	13.0[a]	12.75	13.74	13.25$_w$	11.0	—	—
25 Oct.	2.75	5.25	8.5[a]	11.75[a]	12.5	10.5$_w$	11.75	39.25	—
30 Oct.	18.0	12.0	16.75[a]	19.25[a]	20.5	11.5$_w$	10.6	74.75	—

[a] Ants active at this depth
[b] Permanent placement of heater
$_w$ water table level to nearest decimeter

higher burrows after the placement of the electrical heating rod. The heating rod increased the temperature of that part of the mound by as much as 9.75°C. Before the heating rod was in place, the only special quality of the peat just above the water table was that it had the highest temperature available to the ants. The ants definitely preferred levels in the mound with higher temperatures. No doubt the higher mound temperatures in the summer months would be found at the surface, and one would expect the ants to be active nearer the surface at that time of year.

Soil Moisture Preference

Moisture available to the soil in the part of the mound occupied by ants was always 100%. Drier strata were available to the ants on 13, 16, and 18 October. Although the percent moisture available to the soil is not a measure of relative humidity, the soil surrounding the ant-occupied burrows was saturated. Therefore, I assume that the air in the burrows was close to, if not at, 100% relative humidity. These wetland ants did not differ markedly from those studied by von Frisch (1974) which preferred 100% relative humidity.

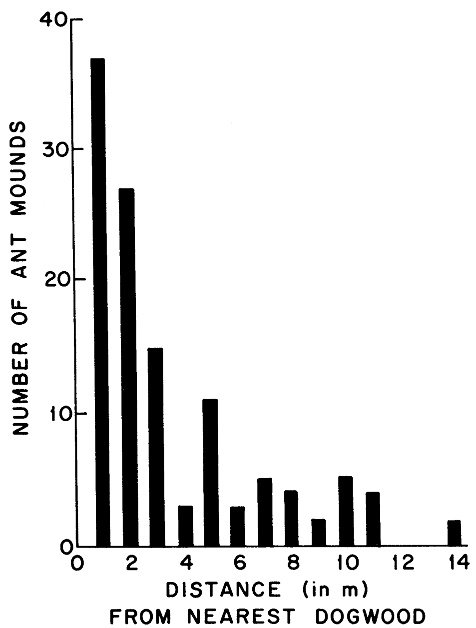

Fig. 3. Number of ant mounds vs. distance from dogwood shrubs.

Part II

Association of Ant Mounds with Vegetation

Mounds were most likely to be near a red-osier dogwood (see figure 3). Red-osier dogwood is a species that tolerates a great deal of water in the soil, but, like the wetland ants, it cannot tolerate permanent submergence of the entire root system. Wetland ants can only survive between the wetland surface, somewhat elevated by their mound, and the water table. With the water table fluctuating as a result of precipitation, artesian water sources, and evapotranspiration during the growing season, the thickness of habitable peat available to these ants changes constantly. A habitat that consistently offers a greater vertical space between the wetland surface and the water table will also offer a greater range of temperatures and humidities. Maximizing this vertical space would be advantageous to an ectothermic animal such as *Formica montana.*

There are many plausible explanations for the observed association between wetland ants and red-osier dogwood:

1) The ants and dogwood are both adapted to a habitat that is not frequently inundated with water.
2) The dogwoods supply the ants with a preferred food source.
3) The dogwoods locally create a suitable ant habitat by evapotranspirative depression of the water table.
4) The ants aerate the soil for the root systems of the dogwood.

Ant Mound Structure

Formica montana mounds are cylindrical. The dimensions of the mounds vary; some mounds are taller than wide while others are

TABLE 2. Number of ant mounds with a specified shape and amount of vegetation covering the top surface.

	Less than ⅓ covered by vegetation	*⅓-⅔ covered by vegetation*	*⅔ to fully covered by vegetation*	*T*
Mound as tall as wide	9	9	12	30
Mound taller than wide	1	16	10	27
Mound wider than tall	21	22	3	46
T	31	47	25	103

Null Hypothesis: The amount of vegetation covering an ant mound is independent of the shape of the mound.
d.f = 4; $\chi^2 = 23.57$; p∠,01

wider than tall. Vegetation is cropped by the ants from the top of some of the mounds exposing bare soil. A chi-square statistic was used to test the null hypothesis that the amount of vegetation covering an ant mound is independent of the shape of the mound. The test revealed that a mound whose width is greater than its height is likely to be void of vegetation on its top, whereas a mound whose height exceeds its width is likely to have an abundance of vegetation on its top ($\chi^2 = 23.57$, p∠0.01; see Table 2).

Assume, as did von Frisch (1974), that a primary function of ant mounds is to increase the surface area exposed to solar radiation, thereby facilitating heating. The data suggest the hypothesis that wetland ants first build their mounds up, and then out, in order to maximize the amount of mound space with preferred temperatures and humidities. The larger the mound, the more ants reside therein. All the ants of a mound are closely related, being the offspring usually of one queen (Wilson 1970). Time is needed to build a population and a mound large enough to house it. The largest mounds are the widest mounds. Since the largest mounds are most likely the oldest, and the narrowest mounds most likely the youngest, ants first build their mounds up and then out. By building their mounds up the ants create a larger vertical habitat subject to a larger range of temperatures and humidities. By building the mounds out, the ants keep the surrounding grasses and sedges from shading the top of the mound. By cropping the top vegetation, the ants allow direct heating from solar radiation incident on the mount top. Once again, the range of temperatures and humidities available to the ants increases. Ants are ectothermic; therefore any architectural adaptations providing them with a greater range of temperatures and humidities would certainly be selected for.

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THE IMPACT OF NATIVE AMERICANS ON PRESETTLEMENT VEGETATION IN SOUTHEASTERN WISCONSIN

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Abstract

Indians occupied southeastern Wisconsin long before European settlement, utilizing and influencing native vegetation. The magnitude of this influence was studied using the General Land Office surveyor's notes and historical, ecological and archaeological literature. About 15,000 Potawatomi and Winnebago Indians lived in SE Wisconsin immediately before European settlement. Their summer villages and associated winter camps occupied about 1500 acres of cleared land (0.06% of the region). There is little evidence in the surveyor's notes of direct impact on vegetation but other references note Indian fires and dispersal of favored plant species. Other evidence indicates that lightning fires occurred in the region. Apparently, native Americans in presettlement southeastern Wisconsin had little direct impact on the landscape but their indirect influence through fire was probably appreciable.

INTRODUCTION

The influence of native Americans on natural vegetation has been examined in several parts of North America. Day (1953) examined the role of Indians in the northeastern U.S. and concluded that their use of fire had a major effect on presettlement vegetation. However, Martin (1973) reviewed the historical record in the same region and concluded that lightning was a more likely cause of fire since eastern tribes appeared to lack fire-setting rituals. Russell (1981) noted the infrequent occurrence of Indian clearings in early descriptions and surveys of northern New Jersey. Lewis (1980) reported on the ritualistic use of fire by several western Canadian Indian tribes. Barrett (1980) described the impact of Indian fires on vegetation in western Montana. In Wisconsin, Curtis (1959) noted several historical references to Indian-caused fires and concluded that Indian fires determined the presettlement vegetation in southern Wisconsin, especially by maintaining prairies and savannas. Hibbard (1904) noted a 400 acre corn field of the Sauk and Fox tribes in Sauk City along the Wisconsin River. This report describes settlement patterns of native Americans in southeastern Wisconsin just before extensive European settlement and Indian impact on the vegetation through land clearing, fire and other activities.

METHODS

Information on Indian village and campsite location, population sizes, and patterns of subsistence and resource utilization were needed to examine the impact of Indians on vegetation. Historical and archaeological publications were reviewed. Information on modern lightning fire frequency was obtained from the Wisconsin Department of Natural Resources publications. The General Land Office (GLO) surveyor's notes from 1836-37 were used to develop detailed vegetation maps (see Dorney 1980 for details). These

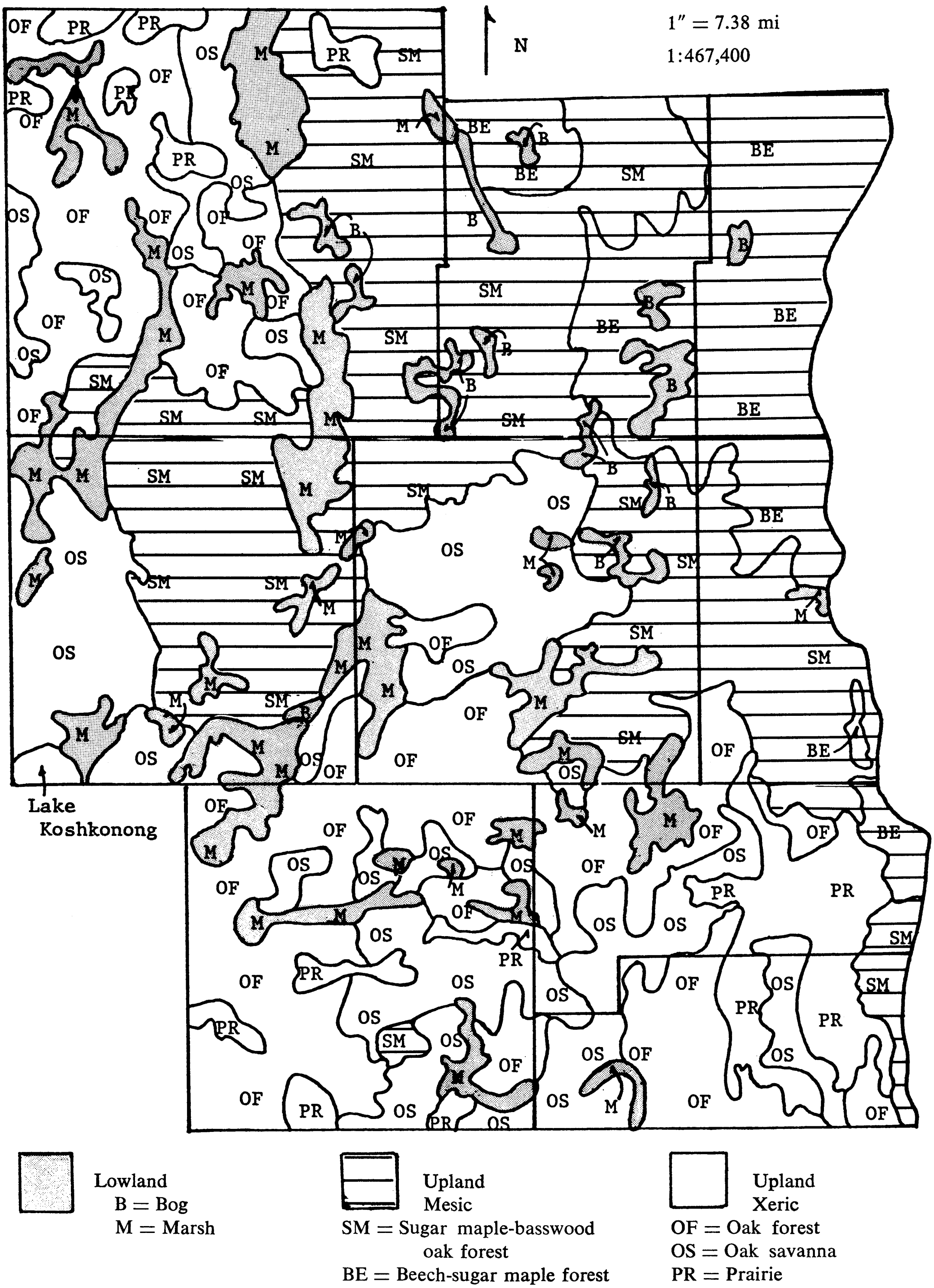
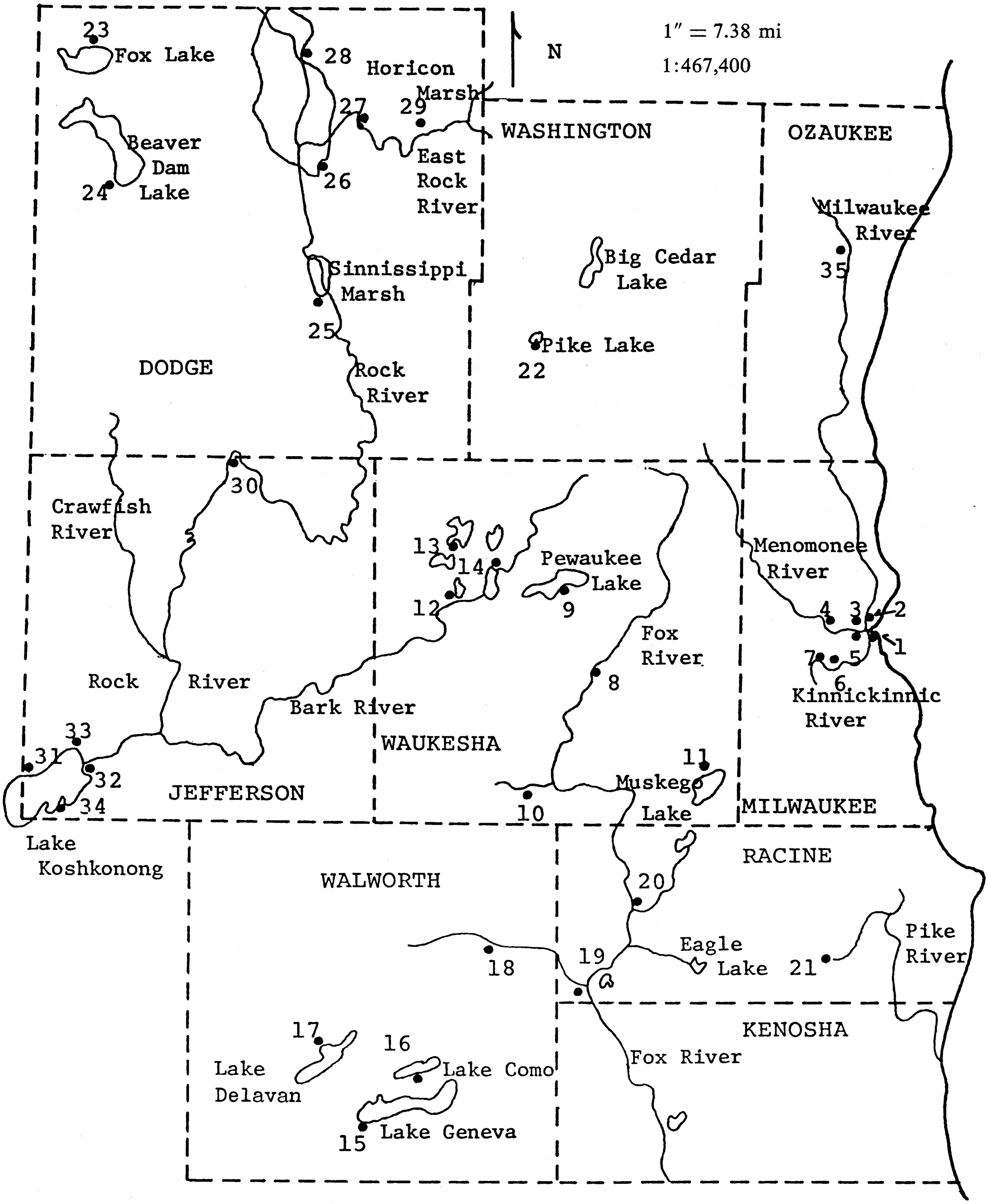


Fig. 1. Presettlement vegetation of southeastern Wisconsin (from Finley 1976).



POTAWATTOMI VILLAGES 1-21

WINNEBAGO VILLAGES 22-34

OJIBAWA VILLAGE 35

Fig. 2. Indian Village Sites in S.E. Wisconsin: late 1820's and 1830's.

notes were also examined for mention of Indian village sites.

Results

Presettlement Vegetation

Oak forest was the predominant vegetation type in SE Wisconsin before European settlement and occupied 18.5% of the region (Fig. 1). Sugar maple-basswood-oak forest (17.9%) was predominant in the north but toward the south was restricted chiefly to locations adjacent to Lake Michigan. Beech-sugar maple forest (8.5%) was present along Lake Michigan. Oak savanna (14.9%) and prairie (8.3%) were also common especially on the southern and western portions of the region. Open marsh (12.3%) was the most common lowland vegetation type. Tamarack bogs (3%) were present on organic soils mostly in the northern part of the region.

There was no significant correlation between vegetation and soil properties such as drainage class, slope, texture, or available soil water, based on a multivariate discriminant analysis among major vegetation types. For instance, oak and sugar maple forest occupied similar soils. Most of these forests occurred on sites with slopes less than 6%, on well drained clay loams and silty clay loams and on sites with four to six inches of available soil water (Dorney 1980). Instead, the vegetation pattern reflected differing degrees of disturbance, primarily caused by fire. Fire dependent vegetation such as prairie and oak savanna were generally found west of fire barriers formed by wide marsh/river complexes, such as the Rock River. The predominance of prairie, oak savanna and forest in Racine, Kenosha and Walworth Counties apparently resulted from the absence of effective fire barriers. Soil differences can be ruled out since silt loams occupied by prairie and oak savanna were similar to those supporting sugar maple-basswood-oak forest in the northern part of the region (Dorney 1980).

Presumably, fire was more frequent westward and southward where fire dependent prairie and savanna were more abundant. Other ecosystem properties such as tree density and abundance of fire tolerant species also indicated frequent fires. Based on present weather data, tornadoes were infrequent events with a calculated return time of 2930 years. In contrast (based on vegetation types present), fire showed an estimated average return time of 16 years west of fire barriers and 112 years east of them (Dorney 1980).

Indian Population and Settlement Pattern

Southeastern Wisconsin (like the rest of the state) experienced numerous changes in Indian populations, tribes and settlement locations. This became especially evident after the fur trade began in the 1700's. The fur trade may have caused a considerable change in Indian lifestyle and settlement patterns (Kay 1977). The Iroquois wars also had a major influence on Indian settlement. These wars drove the Potawatomi from Michigan and Indiana to eastern Wisconsin. There they initially occupied the western shore of Lake Michigan and gradually spread southward and westward into the Milwaukee area (Lawson 1920).

By the late 1700's and early 1800's, the Potawatomi controlled the Lake Michigan shoreline from Kewaunee to Kenosha and inland to Walworth County (Fig. 2). To the west, mostly along the Rock River drainage, the Winnebago were numerous. Menomini and Chippewa were also present in smaller numbers often living in Potawatomi villages where the city of Milwaukee now stands.

The Potawatomi and Winnebago were semi-sedentary people who lived in semipermanent summer villages. In the winter, they left these villages for smaller, more numerous hunting camps. By the early 1800's the population had increased and village fragmentation occurred (Kay 1977). In the winter, the Winnebago hunted in the

Madison area while the Potawatomi usually camped within 20 miles of their main village (Kay 1977). Summer villages had extensive agricultural fields where corn, tobacco, beans and squash were grown. Pumpkins, melons and potatoes are also mentioned (Jones 1974).

In the spring, Indians gathered at sugar maple camps for the spring "sugaring"; later, they moved to summer villages to plant crops. Summers were spent in the village tending gardens while hunting and gathering nearby. Harvest of crops and wild rice in the fall was followed by a communal deer hunt. Village groups then broke up into smaller winter camps for trapping and hunting. Fishing was a common activity, especially for coastal tribes (Kay 1977). The impact of European settlers on this pattern is not clear. Kay (1977) believed that disruption of settlement patterns and lifestyle was dramatic; for example, fall fishing camps were abandoned in favor of fall trapping. Spector (1974) thought that the Winnebago lifestyle changed little after contact.

Population size varied considerably as a result of tribal boundary changes, trading post locations and disease. Population estimates were provided for most of the villages mentioned in the historical literature. However, there were no estimates for 14 of the 35 villages cited. It was assumed in this analysis, that these villages were small and arbitrarily assigned a population of 50 people. Evidence suggests that between 1820 and the late 1830's, about 14,700 Indians lived in SE Wisconsin; of these, 8700 were Potawatomi and 5950 were Winnebago (Table 1). There was one small Ojibawa village in Ozaukee County. Milwaukee, Waukesha and Dodge Counties had the highest populations, a result of association with the fur trade and favorable environmental features such as extensive marshes, rivers and large lakes.

Indian Impact on Their Environment

Settlement locations were fairly well documented, especially in the *Wisconsin Archaeologist* (Brown 1906, 1908, 1909, 1911, 1925 and 1926a,b,c). Sizes of the settlements and agricultural fields were not always recorded and density varied. Thwaites (undated) referred to a Potawatomi village on the Manitowoc River stating that "It must not be understood that all this described territory [the village site] was densly [sic] covered by lodges . . . rather [it] was occupied by detached groups of greater and smaller size as well as solitary huts here and there." Actual cleared areas associated with villages are unknown. Therefore, it was assumed that the entire village site was cleared. This yields a maximum estimate for cleared land which was probably not achieved.

Acreage and population data were avail-

TABLE 1. Location and size of Southeastern Wisconsin Indian villages in the late 1820's and 1830's.

Tribe and Village Location	*Population*	*Village Size*	*Surrounding vegetation*	*Reference*
Potawatomi				
Milwaukee County				
1. Jones Island	200 to 500	21 acres	Marsh	2
2. East Water Street	200	13 acres	Sugar maple forest	2
3. Kenozhaykum's Camp	100	6 acres	Sugar maple forest	2
4. Lime Ridge (Bread's)	2000	24 acres	Sugar maple forest	2
5. Pauchkenan's (Walker's Point)	1200	n.a.	Sugar maple forest	2
6. Muskego Avenue	150 to 200	n.a.	Sugar maple forest	2
7. Layton Park	200	n.a.	Sugar maple forest	2

Tribe and Village Location	*Population*	*Village Size*	*Surrounding vegetation*	*Reference*
Waukesha County				
8. Waukesha City	2000	14 acres corn 121 acres village	Sugar maple forest	5, 10, 12
9. Pewaukee	540	n.a.	Oak savanna	5, 10, 12
10. Muckwanago	300 to 500	n.a.	Oak forest	5
11. Muskego Lake	300 to 400	n.a.	Sugar maple forest	5
12. Nemahbin Lake	50[a]	n.a.	Oak savanna	4
13. Oconomowoc Lake	50[a]	n.a.	Sugar maple forest	4
14. Nagawicka Lake	50[a]	n.a.	Oak savanna	4
Walworth County				
15. Lake Geneva	500	n.a.	Oak forest	8
16. Lake Como	50[a]	n.a.	Sugar maple forest	6
17. Lake Delavan	50[a]	n.a.	Oak forest	9
18. Spring Prairie	50[a]	n.a.	Oak forest	1
Racine County				
19. Burlington	50[a]	n.a.	Prairie	15
20. Waterford	50[a]	n.a.	Oak forest	15
21. Skunk Grove	50[a]	n.a.	Prairie	1, 15
Winnebago				
Washington County				
22. Pike Lake	50[a]	n.a.	Sugar maple forest	7
Dodge County				
23. Fox Lake	86	n.a.	Oak forest	7, 11
24. Beaver Dam Lake	150	several acres of corn	Prairie	3, 11
25. Hustisford	10	n.a.	Oak savanna	11
Horicon Marsh Area				
26. Site 1	2000	n.a.	Sugar maple forest	1
27. Site 2	50[a]	n.a.	Sugar maple forest	1
28. Site 3	1500 to 1800	n.a.	Sugar maple forest	1
29. Theresa	50[a]	n.a.	Sugar maple forest	1
Jefferson County				
30. Watertown	400	10 acres corn	Sugar maple forest	13
Lake Koshkonong Area				
31. Carajou Point	1200	n.a.	Oak savanna	14
32. Burnt village	167	10 to 15 acres	Oak savanna	14
33. Site 3	21	n.a.	Oak savanna	14
34. Site 4	50[a]	n.a.	Oak savanna	14
Ojibawa				
Ozaukee County				
35. Port Washington	50[a]	n.a.	Sugar maple forest	1

[a] Populations estimated
n.a. Data not available

Tribal Totals

Potawatomi	8,900 to 8,690 people
Winnebago	6,034 to 5,734
Ojibawa	50
Total	14,984 to 14,474 people

References

1. Brown 1906
2. Brown 1916
3. Brown 1922
4. Brown 1923[a]
5. Brown 1923[b]
6. Brown 1926[b]
7. Brown 1926[c]
8. Brown and Brown 1928
9. General Land Office Surveyor's Notes, 1836
10. Haskins 1909
11. Lawson 1920
12. Porter 1902
13. Sohrweide 1926
14. Stout and Skavlen 1927
15. West 1903

able for 10 of the 35 villages. These data suggest ratios of 15.2 people/acre for village sites and 35.1 people/acre for agricultural fields. Thus, SE Wisconsin summer villages and fields occupied about 970 acres from 1820 to 1830. Winter camp acreages (for which no data are available) were estimated by subtracting the acreage of agricultural fields from that of summer villages. On this basis, about 1500 acres of land were cleared by Indians in SE Wisconsin just before settlement or about 0.06% of the region. These clearings were concentrated near Milwaukee (403 acres), Waukesha (370 acres) and Horicon Marsh (428 acres). About 80% of the population lived in these three areas.

Comparison of the presettlement vegetation and Indian settlement patterns (Fig's. 1 and 2) reveals little apparent tribal preference for major vegetation types. The Potawatomi lived mainly east of fire barriers in sugar maple-basswood-oak forest while the Winnebago lived chiefly in oak forest and savanna adjacent to fire barriers such as the Rock River. There were numerous exceptions (Table 1). Winnebago villages near Horicon Marsh were in sugar maple forest while the Potawatomi villages near Waukesha were in oak savanna and those in Racine County were in prairie. The most populous Winnebago and Potawatomi villages were in sugar maple-basswood forest near rivers or marshes. This probably reflects more available food resources in these sites than in oak forests and savannas. There was no association of Indian sites with disturbed vegetation types (such as brush or aspen forest) perhaps reflecting lack of detail available from the GLO surveyor notes. It is also possible that, since most of the regional vegetation reflected frequent disturbance by fire, the effect of Indian settlements was not as easily observable as it would have been in a less frequently disturbed area.

Indirect effects were probably more extensive than land clearing. Indians have been reported to set fires to maintain open lands, clear agricultural fields and modify wildlife habitat (Day 1953). There is no record of systematic fire-setting rituals in the Winnebago or Potawatomi cultural literature. This is in contrast to the practices of some western Canadian tribes who have an annual fire-setting ritual in the prairie (Lewis 1980). However, it appears that the Winnebago used fire to affect vegetation occasionally. Lathrop (1856) refers to a prairie fire in Racine County in 1835 blamed on the Indians. A prairie and woods fire in the Turkey River area near the Mississippi was set by Winnebago to drive game (Beltami 1828) and other Winnebago's used annual fires to clear brush for hunting (Schafer 1929). Other references to Indian fires in Wisconsin include a grass fire set in 1831 by the Menomini near Lake Butte des Morts (Porlier 1900).

Data on lightning fire frequency in southeastern Wisconsin are poor, since DNR records are based on information supplied irregularly by local fire departments (E. Trecker, personal communication). Data from northern Wisconsin are collected systematically and are more accurate. They indicate that lightning is a minor cause of forest fires. From 1970 to 1978, 97 lightning-caused fires occurred in northern Wisconsin yielding an average of twelve fires/year or 0.00000198 fires/mi^2/year (Wisconsin DNR 1970 to 1978). Thunderstorms are somewhat more frequent in southeastern Wisconsin than in the northern part of the state (U.S. Weather Bureau 1952) and a few lightning-caused forest fires have been reported in southeastern Wisconsin (Wisconsin DNR 1971 and 1977). Applying the northern Wisconsin lightning fire rate would produce an average of five lightning-caused fires per year in SE Wisconsin. The effective rate may have been somewhat lower in non-forested areas but even there lightning can be an important ignition source (Vogl 1974). Based on these data, one can conclude that lightning-caused fires were present in southeastern Wisconsin before European settlement.

There is evidence that Indians intentionally moved plants useful for medicinal and food purposes. Black (1978) discusses transport of sweet flag (*Acorus calamus*), butternut (*Juglans cinerea*), Canada plum (*Prunus nigra*), chokecherry (*Prunus virginiana*) and wild strawberry (*Fragaria virginiana*) by Algonquian tribes in Quebec. She also mentions gooseberry (*Ribes cynosbati*), *Amelanchier*, hawthorn (*Crataegus* sp.), and wild rice (*Zizania aquatica*) as possible candidates for Indian transport. Yarnell (1964) mentioned evidence for transport of chestnut (*Castanea dentata*), Canada plum, Kentucky coffee tree (*Gymnocladus dioicus*), *Nelumbo, Apocyanum androsaemifolium* and *A.cannabinum, Asclepias tuberosa* and *A. syriaca* and *Urtica gracilis* by New York and east coast tribes. Beltami (1828) observed a beech tree along the Mississippi River near Minneapolis. It was revered by local Indians and probably planted since this location is far beyond the range of beech. In Wisconsin, Curtis (1959) noted the association of Kentucky coffee trees with some Indian village sites. Smith (1923) mentioned the transport of *Ptelea trifoliata* by Menomini Indians into their reservation from Kansas. It appears likely that Indians moved valuable plants to fulfill their needs.

Plant harvesting must have produced a widespread effect. Apparently, there has been no attempt to estimate the amount of wood needed to cook and smoke fish and meat, boil maple syrup and warm wigwams, but it was probably considerable. Many native plants were gathered for food, medicine, dyes, cordage and smoking materials. Smith (1923 and 1933) examined the ethnobotany of several Wisconsin tribes and listed the uses of numerous species. Curtis (1959) believed that gathering had little effect on plant populations in the state with the possible exception of *Psoralea esculenta* which was prized for its fleshy root.

Hunting and trapping may have affected vegetation indirectly. There is good evidence that Wisconsin Indians overtrapped beaver, deer and otter (Kay 1977). The decrease in beaver dams probably reduced the sedge meadow habitat in the region. If deer populations were low, favored browse species (such as Canada yew-*Taxus canadensis*) may have benefited. Indians probably hunted local elk and bison to extinction along the Fox River in northeastern Wisconsin and elk were extirpated from the state before extensive European settlement began (Kay 1977). These indirect impacts probably had a negligible effect on the regional vegetation.

CONCLUSION

Several Midwestern studies have examined the settlement pattern of Indians in relation to vegetation. Dustin (1930) studied Indian sites in Saginaw County, Michigan, and concluded that most villages were near navigable water and marshes where game and food plants were abundant. Sugar maple forests were also favored. Jones and Kapp (1972) examined the relationship of presettlement forest pattern to Indian settlement in Bay County, Michigan. In a bog pollen profile, they found an increase in *Ambrosia, Populus* and *Typha* from 35 to 325 A.D. which may reflect an adjacent Indian site occupied at that time. The tribes living in Bay County at the time of European settlement were not discussed but from the maps of Jones and Kapp, it appears that dense sugar maple-beech-hemlock forest was avoided by the Indians in favor of oak-ash forest and proximity to major river valleys. Bowman (1974) working in southern Ontario determined that large white pines present at settlement had developed on abandoned Huron Indian agricultural fields.

In southeastern Wisconsin, most of the 35 villages were located near large rivers and marshes where travel was easy and food plentiful. Apparently, the tribes showed little preference for different vegetation types. Most Potawatomi villages were in sugar maple-basswood-oak forest but Waukesha area villages were in oak savanna. Winnebago villages were mostly in oak forest and savanna but the villages near Horicon Marsh were in sugar maple forest. The GLO surveyor's notes show no evidence of direct effects of a village on vegetation. However, this may be a reflection of the generally low level of detail available from this source.

Just before European settlement, there were about 15,000 Potawatomi and Winnebago Indians living in southeastern Wisconsin. It is estimated that these people cleared about 1500 acres of land or about 0.06% of the region. Clearings were concentrated near Milwaukee, Waukesha and Horicon Marsh. Although there was no observable relationship between disturbed vegetation and Indian sites, there is strong circumstantial evidence that fire was used especially by the Winnebago tribe. Likewise, the vegetation pattern provides strong evidence of frequent fires especially west of large river/marsh complexes. Other activities such as wood gathering, plant collecting and hunting probably had local impacts. There is also evidence for lightning-caused fires in the region. However, these were infrequent and probably not sufficient in themselves to account for the vegetation pattern. Since the largest villages were in sugar maple forest, this also indicates that Indians were not the sole cause of fire. Fire, the most important disturbance factor in the presettlement vegetation of southeastern Wisconsin, was probably caused by both Indians and lightning.

Acknowledgments

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HYDROLOGY AND CHRONOLOGY OF A PEAT MOUND IN DANE COUNTY, SOUTHERN WISCONSIN

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Abstract

This study describes the hydrologic conditions that have caused the formation of a three hectare peat mound. This wetland is elevated two meters above the adjacent 100 hectare Waubesa Wetlands and has developed at the transition area between upland and lowland.

Results from 37 hydrologic stations located on the mound indicate the existence of an artesian source of water beneath the peat. Because of the ability of clay layers to confine an aquifer more than silt and sand layers, the stratigraphy of the mineral soil beneath the peat may dictate the amount of vertical flow of water and thus the height to which the peat can accumulate. The rate of groundwater flow and the topography of the artesian site determine whether peat will accumulate. The beginning of peat formation at the mound is dated at 7500 ±80 years before present (WIS-1265).

INTRODUCTION

The purpose of this study is to describe the hydrologic conditions that have caused the development of a peat mound, an elevated wetland which has formed at the transition between upland and lowland. The study site is a three hectare portion of the 100 hectare Waubesa Wetlands located in Dane County, southern Wisconsin (Figure 1). In southern Wisconsin peatlands are typically located in local depressions of the landscape where water levels are relatively high throughout the year (Bedford, *et al.* 1974). They often form in a manner similar to the way the majority of Waubesa Wetlands formed, by the accumulation of organic matter in a shallow lake bay or lake (Friedman, *et al.* 1979). The peat mound examined in this study is different from the more typical basin-filled peatlands of the region in several respects.

First, its surface is elevated two meters above the adjacent basin-filled wetland. This is remarkable because for peat to accumulate the water level must be at or near the surface of the peat throughout the year. The high water levels retard the rate of decomposition, so that rate of productivity of organic matter exceeds the rate of decomposition. The difference in elevation between the mound and the basin-filled wetland implies a dramatic change in the elevation of the water table over a relatively short distance in the peatland. The water table, and hence the surface elevation of the peat, drops nearly two meters in less than 40 meters of horizontal distance (Figure 2). This is an exceedingly steep slope for peatlands in this region. Only blanket bogs in Great Britain and Ireland exhibit steeper slopes (Moore and Bellamy 1974).

Secondly, the three-dimensional shape of the peatland is convex, not flat or concave like a typical basin-filled wetland. In this respect the mound is more similar to raised *Sphagnum* bogs that occur 800 km to the north (Heinselman 1970).

Finally, although lake sediments (gyttja) underlie the basin-filled portion of Waubesa Wetlands, no lake sediments underlie the

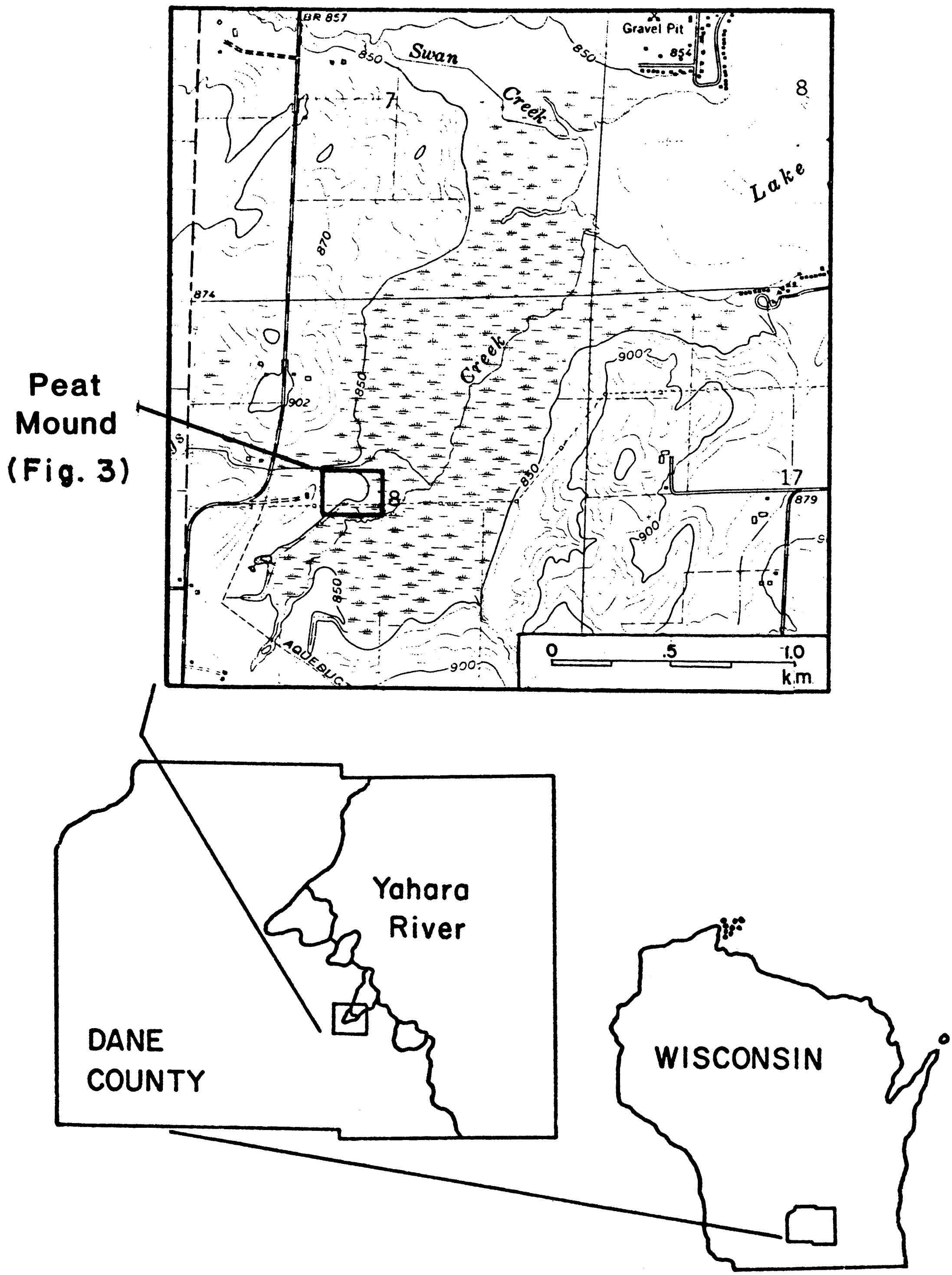

Fig. 1. Map of Waubesa Wetlands and its location in Wisconsin. The peat mound is shown in more detail in Figure 3.

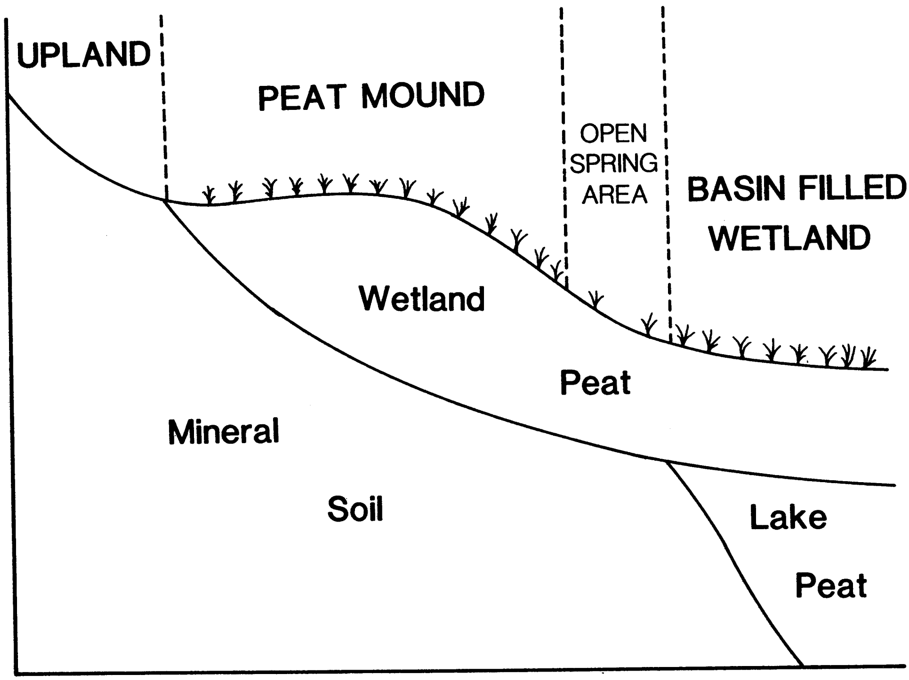

Fig. 2. Schematic diagram showing the relative positions of the peat mound and open spring area in relation to the upland and basin-filled wetland.

one to two meters of peat of the mound. The lack of underlying lake sediments implies that the peat did not form through a basin-filling process typical of many peatlands in the region.

This preliminary study provides a description of the physical conditions that have caused the development of the mound. Because the source, distribution, fluctuation and flow of water are central to the development of peatlands, we have taken a hydrological approach.

The Study Area

The site is near a terminal moraine that marks the extent of Wisconsin glaciation 13,000-17,000 years ago (Mickelson and McCartney 1979). A drumlin is located immediately next to the peat mound. Beneath the glacial till are layers of sandstone (Cline 1965). Artesian springs are common in the region, and occur at the base of the mound.

The vegetation was disturbed by plowing and the planting of reed canary grass, *Phalaris arundinacea,* about 50 years ago. The reed canary grass still dominates the site, and therefore the peatland is classified as a degraded fen (Curtis 1959). *Gentianopsis procera* occurs in comparative abundance in patches on the top of the peat mound (Burr 1980), and the groundwater is mineral rich. Other plants at the site which are characteristic of sedge meadows or wet prairies but are also found in fens are *Carex stricta, Andropogon gerardii,* and *Spartina pectinata* (Bedford, *et al.* 1974). *Cornus stolonifera* occurs in patches at both the top of the mound and in the basin-filled portion of the wetland, but not on the slopes, where *Phalaris* dominates.

One to two meters of fibrous sedge peat has accumulated in the study area. The top 50 cm is more decomposed than the deeper peat.

The site is owned by The Nature Conservancy.

METHODS

Surveying. We established a 50 × 50 meter grid system on the mound using wooden stakes to mark the intersection of the grid. From this grid we defined a coordinate system to allow horizontal control at the site. All positions on the mound can be located by two coordinates.

To determine relative elevations of the surface of the mound, we leveled approximately 200 points using a Leitz automatic level. We produced a contour map with 40 cm contour intervals using computer assisted two-dimensional interpolation and smoothing routines (Figure 3). Back-checking with actual data showed the interpolation and smoothing routines did not distort the data. Smoothing was necessary because of the high degree of microrelief on the mound, caused by sedge tussocks and ant hills.

Hydrology. Thirty-seven hydrologic stations were established on the peat mound. Thirty are located on a 25 meter grid system (Figure 3). The other seven are located 10 meters apart on a transect from the top of the mound down to the basin-filled wetland. Each station has a shallow open well (about 50 cm deep) and a piezometer. Each piezometer is a 1.1 cm diameter titanium pipe open at both ends. To prevent the pipe from clogging while it was being pushed through the peat, we placed a loosely fitting bolt into the lower end of the piezometer so that the head of the bolt completely covered the lower opening. After driving the piezometer to the proper depth we lifted the pipe 2 cm, opening the lower end. The bottom

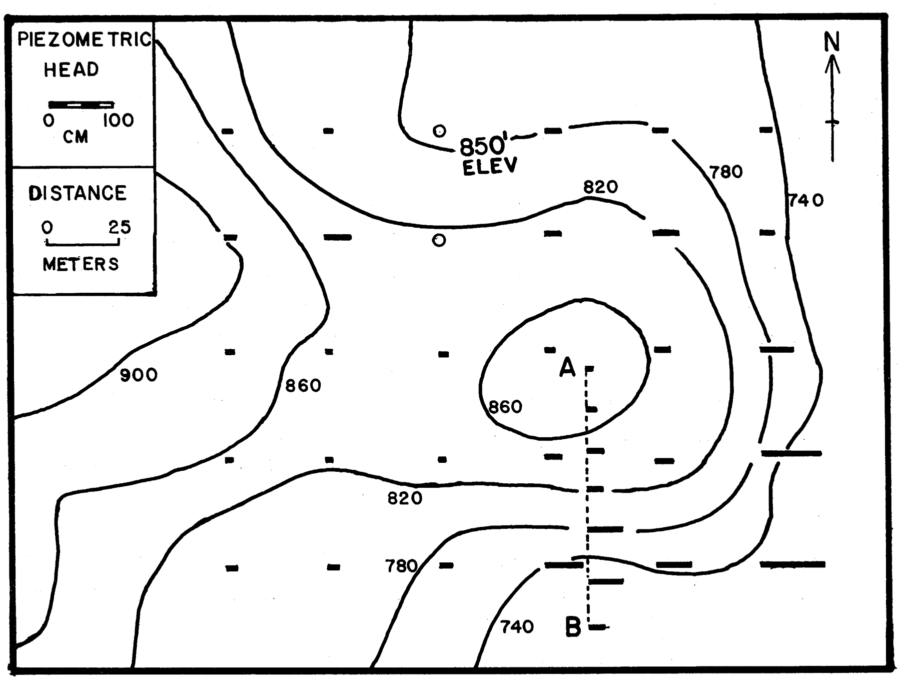

Fig. 3. Contour map of the peat mound showing the location of the piezometric head at the 37 hydrologic stations. Contour interval is 40 cm (relative to arbitrary base station); the 780 cm contour line coincides with the 850 ft. U.S.G.S. contour line (see Fig. 1). A-B marks the transect shown in Figure 4. Hollow circles indicate negative piezometric head (see text).

openings of the piezometers are in mineral soil three to four meters beneath the surface of the mound.

The level of the water in the piezometer measures the hydraulic head of the stratum at the bottom of the pipe. This was compared with the water level in the well. We call the difference between the two levels, the piezometric head. If the water level in the piezometer is higher than the water level in the open well, we arbitrarily called this a positive piezometric head. Water will tend to move upward. The surface elevation at each station is known and elevations are marked on each piezometer.

We measured the elevation of water in each well and piezometer using a wooden dipstick in a four hour period on 13 November 1979, and again on 25 October 1980. There were no substantial differences between the results. Our figures are based on the 13 November 1979 data. Dipstick displacement was calculated and accounted for in the results.

Stratigraphy. We determined the stratigraphy of the underlying sediments at several stations along the transect using Livingstone, Hiller, or Davis peat corers, as well as a standard soil auger.

Laboratory analysis. Pollen and charcoal analysis was done at the Center for Climatic Research. Pollen was scarce but at least 100 grains were counted at each level. Standard pollen analytical techniques were used (Faegri and Iverson 1964).

Results and Discussion

The contour map of surface elevations of the mound shows the existence of a raised dome of peat (indicated by A in Figure 3)

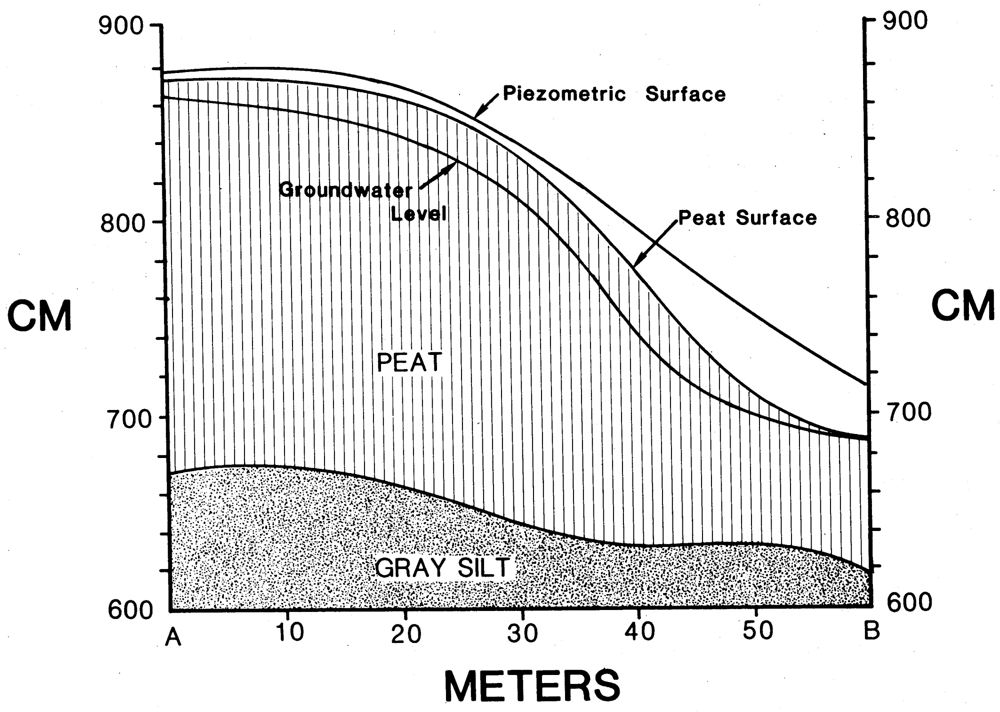

Fig. 4. Cross section of the peat mound, showing the relationship among the piezometric surface, peat surface, groundwater level, and mineral soil (gray silt). The location of the transect is shown in A-B in Figure 3.

nearly two meters above the surface of the basin-filled peatland. The water table closely follows the surface elevations, usually being within 30 cm of the surface. To determine the source of the water in the peat mound, we measured the piezometric head at 37 locations. Figure 3 shows that 35 of the 37 stations have a positive piezometric head, indicating an artesian source of water. We cannot fully explain the anomalous readings at the other two stations, although there may be a very localized perched water table near the two stations. In contrast to the positive piezometric head in the mound, a hydrologic station in the basin-filled portion of the wetland showed no difference in water levels between a piezometer and an open, shallow well. This indicates that the hydrology of the peat mound is qualitatively different than the hydrology of the basin-filled wetland.

The artesian source of water has allowed the peat to accumulate to an elevation nearly two meters above the surrounding basin-filled wetland. To investigate the reasons for the existence and location of the relatively steep slopes emanating in three directions from the raised dome of peat, we placed hydrologic stations ten meters apart along a transect from the top of the mound down to the basin-filled wetland (Figure 3). Figure 4 shows that although there is a good correlation among the piezometric surface, the surface of the peat, and the water table, the piezometric head is greater midway down the slope than on the top of the mound.

It might be expected that a region with a greater piezometric head would be able to supply water to a higher elevation, allowing the peat to accumulate to a greater height, than a region with a lesser piezometric head. The data refute this. Although the top of the mound has a high piezometric head, the slopes have higher heads. The highest piezometric heads are found at the base of the slopes near the open springs (Figure 3).

There are at least two reasons why the elevation of the peat is not positively correlated with the piezometric head. Under very high heads the vertical flow of water may be great enough to prevent any accumulation of peat. This would be the case if there were little resistance to flow in the substrate. Any excess organic matter is dislodged and washed away by the water. This is the most likely explanation of why the open spring area at the base of the mound (Figure 2) still exists after thousands of years of peat accumulation elsewhere in Waubesa Wetlands.

Secondly, if there is substantial resistance to vertical flow through the substrate, a high piezometric head need not be associated with an elevated water table and subsequent peat accumulation. To test this idea, we conducted a preliminary experiment to see if there is greater resistance on the top of the raised sedge meadow. Detailed stratigraphies were determined at both locations. In addition, at the midslope point seven piezometers were placed at various depths in various substrates according to the predetermined

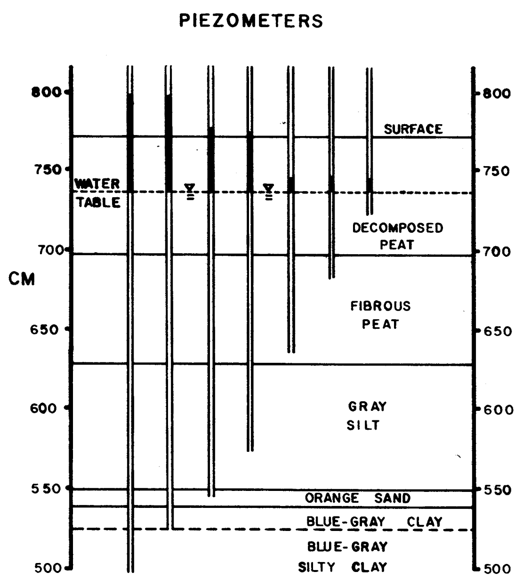

Fig. 5. Piezometric heads (dark lines) at seven levels in the stratigraphy at a midslope point. Note the three distinct levels of the piezometric heads.

stratigraphy. The results are shown in Figure 5.

Although the piezometers were placed at seven depths, there are only three distinct values of piezometric head. Two barriers to vertical flow are suggested by this result. The first is at the boundary between the blue-gray clay layer and the orange sand and the second is at the interface between the gray silt and the fibrous peat. The stratigraphy at the top of the mound differs from the stratigraphy midslope. At the top of the slope there is no blue-gray clay layer beneath the orange sand. Although we have not yet done the piezometric test, the lack of the clay layer probably affords greater vertical flow rates, allowing a higher water table and greater peat accumulation on the top of the mound. In addition, the sand lens may allow significant rates of horizontal flow from the mound to the basin-filled wetland, so that not only does vertical flow meet a greater resistance midslope, but horizontal flow is enhanced. The vertical extent of the water table is thus limited in the midslope region.

Chronology of the Peat Mound Development

The ages of the mineral soil strata and the peat underlying the top of the mound were estimated by correlating pollen spectra taken from various levels with published, radiocarbon-dated pollen diagrams (Friedman *et al.* 1979). The deposition of the mineral soil probably occurred rapidly after deglaciation. Although pollen grains are sparse, half of the grains counted from levels in the mineral soil are spruce. This suggests an age of about 12,500 years before present (L. Maher, Personal communication).

Peat sampled just above the mineral soil-peat interface from a core taken at the top of the mound has been radiocarbon dated at the University of Wisconsin-Madison (WIS-1265) by Dr. Margaret Bender. The date for the beginning of peat formation is 7500 ±80 years before present. This date indicates the beginning of the postglacial warm period in southcentral Wisconsin and the extension of the prairie into this area. It is a minimum date because of the charcoal layer at the transition between inorganic and organic sediment indicating a possibility of burned peat and therefore a hiatus in the core.

A decrease in groundwater supplies caused by a decrease in precipitation and an increase in temperature during this time might have decreased the piezometric head enough to allow peat to be produced and to begin to accumulate. A higher piezometric head would wash sediment away and a smaller head would be too intermittent to give a favorable production/decomposition ratio for build-up of peat. Once the peat begins to build up it acts like a sponge—raising the water table, and the peat acts also as a cap—slowing down the flow of water. The peat, then, accentuates the peat forming conditions and accelerates the accumulation of peat.

Other charcoal layers are common in the peat, suggesting that fires have swept over the landscape and have maintained oak-deciduous forest and prairie vegetation in the region to the present day. The peat mound itself may have also burned during dry periods in the past.

The Significance of Peat Mounds

Because of the importance of artesian sources of water to the hydrology and development of peat mounds, the ecological properties of the mound may differ substantially from other types of peatlands. For example, nutrient cycling, vegetation dynamics, and water relations in a wetland are all dependent to some degree on the hydrological properties of the wetland. Yet very little is known about the ecosystem dynamics of spring-dependent peatlands.

The occurrence of spring induced peat mounds in Jefferson County, southern Wisconsin has been reported by Milfred and Hole (1970) and Ciolkosz (1965). Van der Valk (1975) and Holte (1966, cited in Van der Valk) describe similar systems in northwestern Iowa. Although the vegetation of the

Iowan fens is different from that of Waubesa, the hydrologic setting is similar.

In Europe several authors discuss springs and their effects on peatland development (Hafsten and Salem 1976; Holdgate 1955a, b; Kirchner 1975; Lahermo *et al.* 1977; Moore and Bellamy, 1974; Wickman 1951). But because of differences in water flow, topography, climate, and water chemistry, the peatlands described in these studies are similar to our site only because springs are important in their development.

There is little knowledge of the regional distribution and abundance of peat mounds, but the geologic condition giving rise to these peatlands may not be rare (Ciolkosz 1965; G. B. Lee and J. H. Zimmerman, personal communications). Because these peatlands may often occupy the transition area between upland and more extensive wetlands, they are more subject to agricultural disturbances such as runoff, drainage, and tillage. The vegetation differences between the Iowa fens and the mound at Waubesa Wetlands may be a function of the land use history of each area as well as the climatic and geochemical differences of the area. The Excelsior fen complex in Iowa which has more than eleven peat mounds and associated spring terraces is badly degraded by cattle pasturing although the wetter areas still have *Lobelia kalmii, Eupatorium perfoliatum,* and *Parnassia glauca; Gentianopsis procera* was found at the nearby Silver Lake fen which is an Iowa Natural Area Conservation site (M. Winkler, personal observation).

Ecological processes taking place in this intermediate position in the landscape are important in the coupling of land and water systems (Hasler 1975).

Conclusions

An artesian source of water has allowed vertical accumulation of peat and development of a peat mound. Stratigraphy of mineral soil beneath the peat influences the amount of vertical flow of water and ultimate height of the peat. The mound may be approaching (or may already be at) an equilibrium height.

The peat mound, because of its location between the upland and basin-filled wetland, may act as an important buffer, intercepting runoff of nutrients from the upland. Also, because of their location at the upland-wetland interface, many peat mounds have probably been eliminated or degraded in some way. Because the ecological processes occurring in this kind of peatland are not well known, more detailed research needs to be done before the complexities of this hydrologically interesting ecosystem are understood.

Acknowledgments

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MEASURES OF SYMPATHETIC REACTIVITY IN THE INFANT: A PILOT STUDY TO ASSESS THEIR FEASIBILITY IN MASS SCREENING PROGRAMS

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Abstract

Autonomic nervous system instability has been implicated as a causal factor in the etiology of the Sudden Infant Death Syndrome (SIDS). Measures of sympathetic nervous system reactivity in the infant were therefore reviewed to decide upon a safe, easy and inexpensive method to assess this variable. We conclude that the galvanic skin response (GSR) is the most suitable measure and very amenable to mass screening programs. Difficulties in securing parental informed consent to the conventional method of measuring the GSR, however, necessitated the development of an alternative method which appears promising. While further studies will be required, we conclude that it will be highly feasible to add the GSR to other measures of SIDS susceptability in mass screening programs.

Our objective in this study was to determine whether existing methods for the assessment of sympathetic nervous system reactivity would be suitable for infant mass screening programs. We are most pleased to report that, by all indications, they will. We are confident that pilot programs can be instituted in the very near future.

Our primary intent has been to improve existing mass screening programs for possible susceptability to Sudden Infant Death Syndrome (SIDS). I strongly wish to emphasize at this point that SIDS or "crib death" remains, in the words of the National Sudden Infant Death Syndrome Foundation, "neither predictable nor preventable." Unfortunately, SIDS is still "a disease of theories" and still claims the lives of an estimated 7,500-10,000 babies per year in this country alone.

One theory which has been the subject of considerable recent research and has been well covered in the media is that of sleep apnea. In brief, this simply means that the baby repeatedly ceases to breathe during sleep and eventually never resumes respiration. These apneas have been observed in many SIDS infants prior to death (Steinschneider, 1972; Shannon, Kelly and O'Connell, 1977).

We should first summarize the characteristic epidemiologic aspects of the SIDS. Briefly, the incidence of the syndrome is highest in males, although sex by race interactions exist, in low birthweight infants and in non-caucasians (Bergman, Ray, Pomeroy, Wahl and Beckwith, 1972; Kraus and Borhani, 1972). The SIDS is rare in the neonatal period and after six months. Most deaths occur at two to three months of age (Bergman et al., 1972). Seasonal trends have also been demonstrated with most of the deaths occurring in the early winter months (Kraus and Borhani, 1972). Finally, death appears invariably to occur during sleep (Bergman *et al.,* 1972).

Bergman *et al.* (1972) have proposed that the SIDS results from a spasm of the muscles of the larynx. As evidence they cited the intrathoracic petechiae (small hemorrhages in the lungs and elsewhere) and the fluid blood observed upon autopsy in SIDS victims. These findings are consistent with death due to acute upper airway obstruction.

Our group now believes that multiple causes of SIDS probably exist but that respiratory failure is primary whatever the mechanism. The laryngospasm theory has been recently supported by Leape, Holder, Franklin, Amoury and Ashcroft (1977). These investigators observed respiratory arrest in infants secondary to gastroesophageal reflux. In other words, due to an anatomic malformation, gastric (or stomach) fluids reflux or flow back causing respiratory arrest. They suggested that these infants appear to be true SIDS cases and that the respiratory arrest may have resulted from laryngospasm. Other evidence supports this view (Beckwith, 1978).

The rationale for suspecting that sympathetic nervous system reactivity may be a major factor rests primarily upon the "drowning swimmer reflex." It has often been found that apparent drowning victims have no water in their lungs. It seems highly likely that laryngospasm accounts for these deaths (Wong and Grace, 1963). We further suggest that the high state of sympathetic nervous system arousal associated with the threat of drowning precipitates the spasm. Another reason for suspecting that sympathetic reactivity may be a critical factor in some SIDS cases is the autonomic nervous system instability characteristic of a particular phase of sleep (Hartmann, 1967).

It thus appears that relevant screening programs for SIDS should include a safe, easy and inexpensive test of sympathetic nervous system reactivity. We submit that the galvanic skin response (GSR) or, more properly, the electrodermal response will be most suitable. The GSR defines the state of arousal of the sympathetic nervous system by changes in the electrical conductivity of the skin produced by palmar sweating.

This index of, basically, emotionality or arousal is measured by passing a small electrical current (which can be provided by a six volt household battery) through electrodes placed upon the palms or the soles of the feet. A meter then registers changes in the conductance of the skin measured in mhos.

Weller and Bell (1965) have used the GSR to investigate sympathetic arousal in various behavioral states in 60-110 hour old neonates. They reported that, not only did this measure correlate significantly with several other indices of sympathetic arousal, but that their recordings were not contaminated by movement artifact.

The late Harold Schlosberg (1954) in a witty and delightful review of theories of emotion has emphasized several other attractive features of the GSR which are certainly relevant to mass screening programs. Basically, the device is easily and inexpensively constructed (to quote Dr. Schlosberg: "the whole gadget can be assembled for about $25 and is as portable as a box of cigars") and recordings can be obtained simultaneously from many subjects.

Although the GSR clearly appears to be the best measure of sympathetic nervous system activation in the infant, this method involves passing a small electrical current through the body and we encountered substantial problems in obtaining the informed content of parents. We therefore sought another method of assessing the GSR.

Silverman and Powell (1944) developed a colorimetric technique for the analysis of palmar sweating. They painted the skin with a 25% solution of ferric chloride in ethanol and allow it to dry. A small piece of paper was then saturated with a 5% solution of tannic acid in water and likewise allowed to dry. The GSR as measured by palmer perspiration was then assessed by placing the paper in contact with the skin for three minutes. If the skin is dry no reaction will occur but if perspiration is present the water-soluble ferric chloride will react with the tannic acid to form a blue spot on the paper. The spot ranges from blue-gray to deep blue and the hue is directly proportional to the amount of perspiration present. The intensity of the blue spot can be graded by a densitometer and/or human judges. Silverman and Powell noted that the method is very simple and economical and provides a permanent record which is unaffected by humidity. It thus appears to be a most suitable method for the assessment of the GSR in a mass screening program of the type described should problems of parental consent for the use of the conventional method arise.

We were quite excited when we discovered this system but our primary enthusiasm was short-lived. Tannic acid has recently been placed in category one on the list of known or suspected carcinogens by the Occupational Safety and Health Review Commission. Obviously it will be next to impossible to obtain informed consent for this method also.

It later occurred to us, however, that different chemicals might be used to produce a similar measure of the GSR. Since the reaction involves a salt and a weak acid we accordingly began to experiment with other weak acids. Two of our students performed a "lie detector" experiment using a weak solution of citric acid in place of tannic acid to measure the palmar sweating which accompanies lying. The results were encouraging although the blue spots were pale (Jones and Staples, 1979).

We are, therefore, continuing to explore the use of this method. As subjects become available we will increase the concentration of the ferric chloride solution and experiment with other weak acids to produce an optimal result. We are confident that in this manner we will develop another economical and non-invasive method for the assessment of the GSR in large-scale infant screening programs.

The GSR is, however, clearly only one of a battery of screening procedures necessary for the evaluation of an infant's risk for SIDS. Among others these include evaluation of the sleep respiratory pattern for the frequency and duration of apneas and apnea density by type (Guilleminault, Ariagno, Korobkin, Nagel, Baldwin, Coons and Owen, 1979) and the infant's responsivity to carbon dioxide during sleep (Shannon, Kelly and O'Connell, 1977). Other important measures have been discussed in a recent review (Guilleminault and Korobkin, 1979).

Such screening programs, perhaps coordinated through Wisconsin's excellent network of Regional Perinatal Centers (Graven, Howe and Callon, 1976), now appear to be highly feasible. Such a program appears most desirable also as it could provide vitally needed longitudinal data on the role of infant sleep respiratory patterns and autonomic nervous system instability in the mechanisms of the SIDS.

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FOOD, POPULATION, ENERGY AND THE ENVIRONMENT

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"The third world cannot solve its food problems without solving its energy problems—and without solving both, the road ahead could lead to economic and human chaos. But pointing that road in a better direction will require a massive and well-planned international effort by both science and society." The United Nations University Newsletter, Vol. 5, No. 2, May, 1981.

"Developing country needs for commercial energy consumption in agriculture could jump by nearly five times in the next 20 years. . . . Of the total world commercial energy used in agriculture, the share of developing countries, including China, is about 18%—or the equivalent of 36.8 million tons of oil. But if agricultural production is to increase at target rates . . . energy use will have to expand to 174.5 million tons of oil equivalent by the year 2000, 94% of it in the form of fertilizers and fuel." FAO AT WORK, Feb. 1981, published by the FAO Liaison Office for North America, Washington, D.C.

"Our [the U.S.] ability both to meet domestic demand and to continue to export large amounts of agricultural products is in question because of major uncertainties about future conversion of farmland to nonfarm uses, possible longrun climate changes, future trends in agricultural productivity, future water and energy supplies and costs, and some uncertainty about how much unused cropland is actually available for crop use." The United States may already be sacrificing future yields "by exporting our top-soil to finance oil imports." Statement by Professor Richard Barrows, in *CALS Report*, January-February 1981, Vol. 18, No. 1, University of Wisconsin-Madison, College of Agricultural and Life Sciences.

It has taken 8,000-10,000 years from the beginning of a settled agriculture until the present to increase knowledge enough to produce food for the more than 4 billion people who now live on earth, and perhaps half a billion or more of these remain under-nourished. At recent rates of population growth, the world could have another 4 billion people to feed in about 35 years. Does the world have the resources to feed its growing numbers?

There is obviously no simple answer to this question. The changing pattern of world grain exports (Table 1) over the past 40 years shows increasing deficits (i.e. imports) by growing numbers of developing countries. The traditional grain deficit region, Western Europe, has become more self-sufficient, the developing regions have all increased their dependence on grain imports (although there are a few surplus producing countries in these regions), while the only exporting regions are North America, Australia and New Zealand.

There is, however, a tremendous gap between yields in most developing countries and what they might be. That yield gap represents a tremendous potential food reserve which must be realized in the future. In 1935-39 average grain yields were the same in the industrial and the developing countries, but today there is a difference of 50 percent (Johnson, 1976).

The growing imports of grain by the de-

TABLE 1

(Taken from *To Feed This World* p. 22, by Sterling Wortman and Ralph W. Cumminggs, Jr.; the Johns Hopkins University Press, Baltimore, 1978)

The changing pattern of world grain exports

	Exports (million tons)[a]					
Region	**1934–38**	**1948–52**	**1960**	**1966**	**1973[b]**	**1975[b]**
North America	5	23	39	59	88	94
Latin America	9	1	0	5	−4	−3
Western Europe	−24	−22	−25	−27	−21	−17
Eastern Europe & U.S.S.R.	5	—	0	−4	−27	−25
Africa	1	0	−2	−7	−4	−10
Asia	2	−6	−17	−34	−39	−47
Australia & New Zealand	3	3	6	8	7	8

Sources: Lester Brown and Erik Eckholm, *By Bread Alone*; Lester Brown, *The Politics and Responsibility of the North American Breadbasket.*

[a] Minus sign indicates net imports.

[b] Fiscal year.

veloping countries does not mean that their agriculture has been stagnant. Also, most grain, by far, is still consumed within the same countries where it is produced—only around 10 percent of world grain production moves in international trade. In fact the food supply situation in developing countries of all regions except Africa has improved to some degree during the past three decades. Between the mid 1950s and the mid 1970s, food production in the less developed countries, taken as a group, actually increased at a rate equal to or slightly greater than that of the industrial or more developed countries. However, population growth rates have been, and continue to be, extremely high in the developing countries, recently averaging about 2½ percent per year versus less than 1 percent per year in the high-income, industrialized countries.

World food production has been increasing about .5 percent faster than annual rate of growth in the world's population. However, there is one major difference in the way this increased production was achieved. In the developing countries, expansion of cultivable area accounted for roughly half of the increase in output, and intensification of production on existing acres accounted for the other half. In contrast, in the developed countries almost all the increase resulted from intensification (greater output per acre).

Despite serious inequities in distribution, both approaches have helped world food production keep a few steps ahead of population growth, but both face significant obstacles. Bringing more and more land into agricultural production has, in many cases, created or worsened severe problems of wind and water erosion, soil destruction, overgrazing, desertification, and deforestation. There is more land that can be put into agricultural production (although often of a quality inferior to that already under cultivation). Before converting such land, however, we must recognize the potential consequences of soil and general environmental degradation. Estimates of the amount of land that can be brought into food production without serious environmental repercussions vary widely. Even if one discounts the potential for environmental damage, expansion of cultivable land is not an option available to many countries seeking to increase food production. Available croplands are not always located where population pressures are greatest. India, Bangladesh, and China, for example, certainly do not have a great deal of unused arable land.

The other route toward expanding food supplies is land use intensification, but efforts to make each acre yield more food also confront problems. Highly intensive land use demands great inputs of energy; much of that energy has come from fossil fuels (gas, coal and oil) and from electricity (often manufactured from fossil fuels).

So far, this approach to increasing production has depended on an energy subsidy to the food system: we supplement the sunlight, captured by plants, with stored solar energy captured millions of years ago and preserved in the forms of oil, coal, and gas (Steinhart and Steinhart, 1974). This method of subsidizing agriculture with energy from nonrenewable sources has come about through farm mechanization—the use of tractors, electric motors, and so on, and an ever-growing reliance on fertilizer and other chemicals that are very energy-intensive in their manufacture or, as in the case of nitrogen fertilizer, that depend on petroleum products as a raw material. Irrigation is another means of intensifying land use by providing and controlling water supplies, but irrigation, too, is usually energy-intensive in terms of construction of facilities and frequently in terms of pumping and distribution.

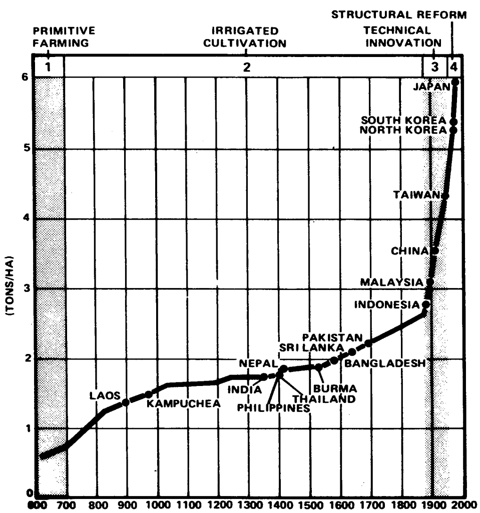
The U.S. now has less than 3 percent of its people actually engaged in farming (USDA Agriculture Handbook No. 561). Other industrialized countries also have witnessed sharp declines in the number of farmers over the past 30 to 40 years. We have replaced horses and mules and human labor with machines. Although these capital- and energy-intensive agricultural systems of the industrial nations have made possible a high standard of material well-being, the increasing cost of energy may require major adjustments in the years ahead.

Once the shift to a mechanized, energy-intensive agriculture has been made, as it has in the industrial countries, it is very difficult to turn back. According to a study by the U.S. Department of Agriculture (The Farm Index, August, 1975), if the U.S. were to return to the technology and the farming practices of 60 years ago, achieving the production totals of today would require about 61 million horses and mules. At present, of course, draft horses and mules are not widely available. The U.S. would also need about 27 million farm workers, nearly 24 million more than we now use. To feed the horses and mules, we would require the production from more than the 100 million acres of cropland currently devoted to the production of farm exports. Thirty percent or more of the population would be in farming, and average family incomes of farmers as well as nonfarmers would be much lower.

In other words, we have achieved our high level of living through the substitution of machines and fossil fuels—finite in amount—for human and animal power, through the intensive use of fertilizers, and through the advances in genetics, farm management, regional specialization in production (itself energy intensive since it increases the need for transportation in the food system), and so on. A return to the practices of 60 years ago would also spell starvation for many people in the world who now depend on U.S. food exports. But, one should add, the entire U.S. economic system is so energy-intensive that even with this energy-demanding agriculture, the entire food and fiber system accounts for only about 17 percent of all the energy used in the United States (USDA Agricultural Handbook No. 561). Personal automobiles, it is estimated, use 27 percent. Food *production* absorbs less than one-fifth of the total energy used in the food system (i.e., about 3.4 percent of all commercial energy used in the United States). More than two-fifths is used for food processing and distribution; homes and commercial eating establishments consume the other two-fifths (USDA Agriculture Handbook No. 561).

Japan also has a highly energy-intensive agricultural system, as do most industrial countries, but Japan has not matched the

U.S. system in terms of mechanization and fuel use. It has, instead, become more intensive than the U.S. in terms of irrigation and the use of fertilizers and other chemicals. Japan's farmers have registered remarkable achievements on the nation's small land area. China, in contrast, has pressed its agricultural output about as far as the use of human power and the recycling of organic matter will permit, and it is now seeking technology to intensify its agriculture in other ways—by producing nitrogen fertilizer domestically and developing its petroleum industry. There are limits to how much food an acre of farmland can produce without the heavy use of fertilizers and other chemicals. Those limits are illustrated in Figure 1, which compares current rice yields in selected Asian countries to the historical growth of rice yields in Japan.



Source: From W. David Hopper, "The Development of Agriculture in Developing Countries." Copyright © 1976 by Scientific American, Inc. All rights reserved.

Fig. 1. Intensification of farming: Current rice yields in selected Asian countries compared to the historical growth of rice yields in Japan (solid line).

(Taken from *To Feed This World* p. 48, by Sterling Wortman and Ralph Cummings, Jr.; the Johns Hopkins University Press, Baltimore, 1978)

As noted earlier, energy-intensive agricultural systems also face serious problems: fossil fuels are getting scarcer and ever more expensive, and the increased use of commercial fertilizers and other chemicals poses environmental risks. In the mid-1970s the world used about 40 million tons of nitrogen fertilizer annually; it is projected that in order to feed the world's population in the year 2000, we will need to use about 200 million tons of nitrogen fertilizer (Hardy and Havelka, 1975). Such increases, plus concomitant increases in the use of insecticides and herbicides, present a serious threat. We simply do not know enough about the consequent ecological imbalances that may result from such vast growth in the use of chemicals. Major problems have already developed. In the Philippines, for example, new high-yielding varieties of rice require a greater density of plants and high rates of fertilization which in turn lead to more weeds and insects. Controlling the pests requires using more chemicals. In wet-paddy rice culture, farmers used to raise fish along with rice in their paddies. Rice with fish plus some garden vegetables was, after all, a pretty good diet. But insecticides kill the fish in the rice paddies, and farmers are now trying to build separate ponds in order to preserve the fish harvest.

This case in the Philippines is simply an illustration of the kind of problems that can result from the increasing use of agricultural chemicals throughout the world. The consequences are sometimes severe and often unpredicted. Obviously, efforts to increase food production, whether through more intensive use of existing cropland or expansion of cultivable area, confront the obstacle of resource scarcity and pose major environmental risks. But just as obvious is the imperative to feed a growing population. What is to be done? This question defies simple solution. There is no easy choice between what is good and right and what is bad and wrong; all choices carry ill effects.

I do not wish to sound like an alarmist in these matters. The world is not, in my judgment, approaching some precipice over which it is about to plummet. Throughout history we find that human beings have proven to be very ingenious, inventive, and adaptive. We will likely create new means of production and new styles of life in response to the shortages that are developing as we pass from a global economy based on fossil fuels to one based on a greater reliance on alternative and renewable sources of energy. We have crossed such "bridges" in energy use before as Figure 2 shows. Past transitions of energy usage may appear to have been easier than the one in prospect because we always seem to have moved from a less compact and perhaps less functional form of energy to a more compact and more concentrated form. However, we are not

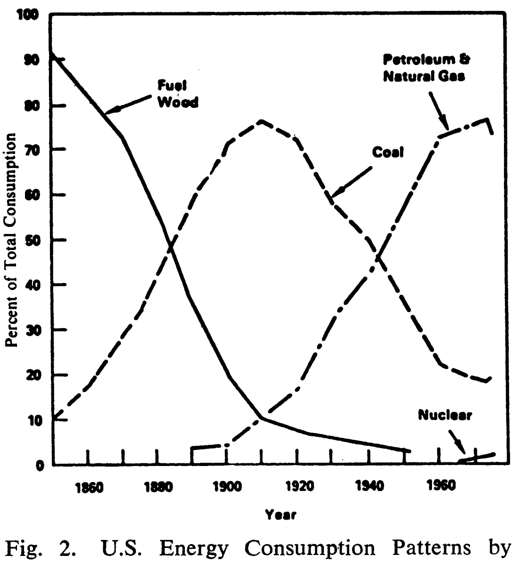


Fig. 2. U.S. Energy Consumption Patterns by Energy Source.*

(Taken from Purdue Farm Management Report, "The Potential for Producing Energy From Agriculture," by Wallace E. Tyner, Agricultural Economics Department, Purdue University, West Lafayette, Indiana)

* Source: Historical Statistics of the United States." Bureau of the Census. U.S. Bureau of Mines.

certain what future sources of energy we will exploit and, when this transition is evaluated in retrospect, it may prove not to have been any more difficult than those of the past.

Regardless of how easy or how difficult this transition proves to be, we must take steps to address the complex problems associated with the interconnected issues of increased food production, rising energy costs, population growth and environmental protection. These steps can be divided into two categories—those that must be taken within the next 10 to 25 years and those that will be feasible only in 50 years or so.

In the short-to-medium term, we must control the rate of population growth. This rate must come down, substantially one would hope, within the next 20 years. The world cannot absorb many more doublings of population every 30 to 35 years, which has been the rate for about the past 30 years. There are, in fact, some encouraging signs that population growth rates are falling. They are already very low in the industrial countries (less than one percent per year, in some cases near zero), and substantial declines in growth rates have been registered in China, Indonesia, and some Latin American countries. Yet we also need to remind ourselves that the number of people is only one part of the issue. The other side of the coin is the per capita consumption rate. And people in the industrial countries, especially in the United States, use much more than their proportionate share of the earth's finite energy and mineral resources. People in the rich countries use almost 100 times as much commercial energy per person as do people in countries with the lowest per capita incomes (World Bank, 1978). We also consume a disproportionate share of grain resources, not directly as grain but as meat after grain has been fed to livestock.

One must be cautious, however, about criticizing the livestock enterprise. Some people tend to condemn all livestock as inefficient converters of grain, and it is quite possible that we will be feeding less grain to ruminants in the future. But livestock farming is essential since it allows humans to consume many plant materials which they cannot consume directly. Livestock can utilize forage grown on marginal lands where grains cannot (or should not) be grown. The emphasis should be on more forage and less grain, rather than eliminating livestock farming. Wisconsin is a leader in forage research, and its leadership has been strengthened by the recent opening of the USDA/North Central Regional Dairy Forage Research Laboratory.

Given the widely accepted view that we are approaching limits to the availability of some critical resources, it does not seem possible that the 70 percent of the world's people living in the developing countries can achieve the resource consumption levels of the 30 percent residing in the industrial countries. Beyond resource limits, the environmental consequences of pursuing such consumption levels worldwide would be disastrous. Therefore, when we urge population control for the poor, we must also urge consumption control and conservation for the rich. The poor people of this world must be given the opportunity to develop their human capacities and to provide for their basic needs of food, clothing, shelter, medical services, and education.

However, a curtailment of per capita resource consumption in the high-income countries does *not necessarily* mean a decline in living standards. Much of our consumption is wasteful. In the short term, for example, the best means for meeting the problem of high energy costs is *conservation*. And the people in the high-income countries, especially those in the United States, can cut energy use very substantially without a major alteration of life styles.

Beyond resource conservation and population control, however, there are a number of measures, now in various stages of research and development, that hold great promise for improving the world food situation. Innovations that produce more food but at the same time decrease the dependence on fossil fuels and minimize the chances for environmental damage are critically important to our future. One area of research involves increasing the capacity of legumes for utilizing atmospheric nitrogen, as well as transferring this capacity for nitrogen fixation to corn and cereal grains. One research team has already developed a corn variety that can capture some nitrogen from the atmosphere, albeit a small amount when compared to the plant's total needs. If this research is ultimately successful, fertilizer demands will fall. Research to increase the efficiency of photosynthesis, the process by which green plants utilize sunlight in the manufacture of organic matter, in order to accelerate plant growth, is also underway (Zelitch, 1975). Scientists have changed the structure of corn plants, for example, to expose more leaf area to the sun and improve photosynthesis. New varieties of barley and wheat with more erect leaves to improve interception of sunlight are already in wide use (USDA Farmline, September 1980). Still other research deals with the domestication of "wild" plant varieties. Of the 3,000 species of plants used for food in the world only about 150 are grown commercially, and of these, 20 supply almost all the food for the earth's more than 4 billion people. We use only a handful of available plants and animals for our food, and particularly all of these were demonstrated by our ancestors several thousand years ago. We have certainly improved upon the food-yielding capacity of these species, but we have not added to the stock.

Research on the development of plants that can grow in saline soils has produced impressive results. On irrigated desert farms in Mexico, a plant with the highest per acre yield of any halophytic (salt-adapted) species tested has a protein content higher than that of wheat. Plant-breeding programs

TABLE 2

(Taken from *To Feed This World* p. 79, by Sterling Wortman and Ralph Cummings, Jr.; The Johns Hopkins University Press, Baltimore, 1978)

Losses of potential crop production by region

Region	Value (million US$)		Losses (%) due to:			Loss as % of potential value	Value of lost production (million US$)
	Actual	Potential	Insect pests	Diseases	Weeds		
North & Central America	24,392	34,229	9.4	11.3	8.0	28.7	9,837
South America	9,276	13,837	10.0	15.2	7.8	33.0	4,561
Europe	35,842	47,769	5.1	13.1	6.8	25.0	11,927
Africa	10,843	18,578	13.0	12.9	15.7	41.6	7,735
Asia	35,715	63,005	20.7	11.3	11.3	43.3	27,290
Oceania	1,231	1,707	7.0	12.6	8.3	27.9	476
U.S.S.R. & China	20,140	28,661	10.5	9.1	10.1	29.7	8,521
World	137,439	207,786	12.3	11.8	9.7	33.8	70,347

Source: Agricultural Research Policy Advisory Committee, *Research to Meet U.S. and World Food Needs.*

to select for greater resistance to insects and diseases and attempts to develop biological methods of insect control by the use of natural predators or pest-sterilization methods also promise to increase food supplies because about one-third of the world's potential harvest is lost to insects, diseases, and weeds (Table 2).

All these diverse lines of research carry major implications for saving fossil fuels and avoiding dangers from over-use of chemical fertilizers and pesticides. Even with research breakthroughs, of course, the world will continue to need inorganic fertilizers and some chemicals for pest control, but a lesser dependence on these chemcials would at least diminish the environmental burden now posed by ever-increasing applications, and it would decrease the demand for the energy needed in the manufacture of inorganic fertilizers and protective chemicals.

Research on better ways to apply available energy in agriculture, especially alternative sources of energy, is also in progress. Systems for producing bio-gas from waste materials, as well as some solar systems, can be used for crop drying, water heating and other purposes. Scientists are working on developing bacteria capable of breaking down tough plant materials such as cellulose and lignin. If their work is successful, it will be feasible to convert wood, cornstalks and other biomass into fuel alcohol. The ethanol currently produced from corn (or sugar cane juice in Brazil) or other substances high in carbohydrates, requires good land to produce the corn. The corn could be eaten directly or fed to livestock. It should be added, however, that the production of ethanol from corn yields a considerable quantity of high protein distillers' dried grains—an excellent feed supplement for livestock.

The promise of all this research does not provide a ready solution to the world's food production and distribution problems. Discoveries in the laboratory or in well-controlled field experiments must be adapted and developed in such a way that they prove practical for farmers. Successful research in biological, physical, and engineering sciences applicable to food production and the development of alternative energy sources may also require new production, distribution and consumption patterns, new property relations, changes in the socio-economic structure, modified financial and other institutions, and indeed entirely new theoretical conceptions of the economic, social, and political world. Institutional innovations and adjustments are imperative if the advantages of new technological developments are to be widely shared; research in economics and the other social sciences, both basic and applied, is strategic to such a transformation. Basic technological shifts in crop production will certainly require changes in farm management practices and quite possibly in the organizational structure of farms and farm businesses, large and small. Some fundamental issues of farm policy, both in the United States and in other countries, will have to be confronted. New issues may very well demand unique policy approaches.

Many of the projects underway on a variety of research fronts may well yield fruitful results within relatively few years. Some new techniques and practices are already being adopted ,and they simply require time to be perfected and applied on a larger scale. As for the more distant future, 50 or more years from now, the outlook can be optimistic *if* we can control growth in population and consumption in the shorter term, *if* the nations of the world can develop procedures to eliminate the constant threat of annihilating civilization with modern weapons of war, and *if* we, as a society, can provide sufficient support for scientific and humanistic research.

We will, I believe, eventually develop more abundant, more reliable, and less depletable sources of commercial energy, and it is unlikely that any one source will dominate the energy scene as petroleum has during the past 30 to 40 years. The "unlimited" prospects of nuclear fusion are still too remote and may not materialize within this period; more promising is the potential of solar energy. A variety of solar technologies are available now. These technologies are expensive, but as the costs of other types of energy increase, they will become more competitive. Mass production and widespread use of solar techniques will also reduce their costs. We need simply to look at what has happened to the real prices of computer technology during the past 20 years to recognize the implications of continued efforts to adapt ever more efficient engineering and production to a growing (and highly competitive) market. These gains in efficiency notwithstanding, however, it is a good bet that the real cost of energy in the future, irrespective of its source, will be higher than that of petroleum before 1973.

One solar technology that seems most intriguing is the photovoltaic cell which converts sunlight directly into electricity. Such cells are now used to power instruments on spacecraft; they could be used commercially, but their cost, although decreasing, is still prohibitive. Since photovoltaic cells can be made from a relatively abundant and nonpolluting element, silicon, the technology faces no major supply constraints and poses no environmental perils. One problem with the technology concerns "shipping" the electric energy from areas where it is produced (presumably in hot desert areas where a great deal of sunshine can be captured and transformed into electricity) to places where it is most needed. Transmitting electrical power by wire over long distances results in a substantial loss. To overcome such distribution problems, physical scientists and engineers plan to convert electrical energy into a chemical source of energy.

If the electric power can be transmitted by wire to a major water source (e.g. in the United States from the Southwest deserts to the Pacific Ocean) this electrical power can be used to decompose water into its elements and thus produce hydrogen gas. Methane can be produced from the hydrogen plus water and limestone. Or, if a liquid is preferable, methonal can also be produced from these same ingrediants. "These chemical vehicles avoid the difficulties not only of intermittent radiation, but also of long-distance transmission. If existent pipeline technology is used which is second only to water transportation in efficiency, fluids can be transported any required distance overland to centers of consumption" (Hubbert, 1978).

Abundant energy supplies do nothing to increase the globe's ultimate stock of mineral resources. Presumably, we can reduce our demands and stretch our supplies of minerals by improving recycling methods, by increasing production and manufacturing efficiency, by enhancing conservation efforts, by using lower-grade ores, and by mining the oceans. While some of these efforts are already underway, most will become more attractive and more feasible once alternative supplies of energy are available. More abundant and diverse energy supplies will also permit new types of agricultural production, including energy-intensive greenhouse production which will reduce our need for tillable agricultural lands and lessen our vulnerability to climatic fluctuations (USDA Farmline, September 1980). Again, such developments would not produce the environmental side effects associated with expansion of cultivable area and intensified production on existing farmlands.

This optimistic outlook seems nearly utopian, at least in physical terms. Are there no physical limits? It seems to me that there *is* an ultimate limit—the environment. We simply cannot keep on growing and doubling population *or* production *or* consumption for very many more generations. Without checks on population, the current population of more than 4 billion people could jump to 8 billion in 30 years and to 16 billion in 60 years, when today's teenagers are still alive. The potential for physical and social catastrophe would also seem to increase geometrically.

Doublings of production and consumption to stay even with or "get ahead" of the demands of a growing population (or the rising expectations of a stable population) also face inevitable limits. Petroleum production, for example, has doubled every ten years since 1900. In each decade, as much petroleum is pumped from the earth as has been extracted in all previous time. By the end of 1963, cumulative world crude oil production had amounted to 150 billion barrels. By the end of 1973 it had reached 299 billion barrels, double the grand total produced by 1963 (Hubbert, 1978). Doubling of production of a finite resource cannot go on many more decades.

Without question, population growth must level off; zero or even negative rates must be the goal. To correct severe inequities in the distribution of resources and income, high income societies must restrain their consumption and help to create opportunities for the poor to improve their standard of living. As we pass through this difficult period of major adjustments, we must support and rely on research and development of reliable knowledge aimed at long-run solutions to the problems of food, population, energy and the environment. All physical resources are finite and limited, but human creativity and intellectual capacity, so far as we know, are not. All other resources become scarcer with increased use, but human knowledge multiplies as a result of use. The ultimate challenge is to expand human knowledge, understanding, and tolerance so that we may have a world of peace and security, a world without hunger and fear.

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THE FUEL GRADE ALCOHOL POTENTIAL OF WISCONSIN'S EXPORT GRAIN AND PROCESS VEGETABLE WASTES

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Abstract

Concentrated and inexpensive biomass in readily bioconvertible waste forms from two agribusiness sectors could be used to produce approximately 23.6 million gallons per year of competitively priced fuel grade alcohol. An additional 8.9 million gallons per year could be produced from these same two sources by the application of more vigorous bioconversion technology. These estimates are based on the quantities and fermentable carbohydrate contents of the Superior grain elevator and statewide vegetable processing industry wastes. Present-day technology appears equal to the task; Wisconsin's on-line fermentation and distillation capacity is large enough to utilize all the generated waste, and estimates of the economics of production present a favorable picture. In addition, both the environment and the waste generating industries would benefit by the elimination of a massive waste disposal problem. Commercial application of the findings reported in this communication could lead to the creation of a viable fuel grade alcohol program equivalent to 86 percent of Wisconsin's fermentation/distillation capacity projected to be on line by the end of 1982.

Introduction

Current fermentation/distillation practices aimed at the production of fuel grade alcohol from biomass rely almost exclusively on traditional grains (wheat and corn) as feedstock. However, at today's cash market grain prices, present-day technology is unable to support the production of a competitively priced product (Converse et al., 1979). Other less expensive feedstocks which are available in large quantities have been considered (wood chips, corn stover, etc.); however, the high degree of lignification of these biomass forms has thus far precluded their cost effective conversion to fermentable sugars (Kosaric et al., 1980). Only concentrated major sources of inexpensive biomass capable of efficient conversion to fermentable sugars can support an economically viable fuel grade alcohol production industry.

Two large-scale sources likely to meet these requirements in the State of Wisconsin are grain and seed dust generated and collected at the Port of Superior grain elevator facilities, and byproduct wastes generated during processing of specialty crop vegetables in the Wisconsin canning industry. The total biomass waste generated annually by these two industries in the State of Wisconsin is about 769,000 tons. The present communication addresses the fuel grade alcohol potential of these two biomass sources with emphasis on efficiency of bioconversion and cost-effectiveness of production.

Materials and Methods

Process vegetable waste samples were collected from the Waunakee plant of the Oconomowoc Canning Company during the 1980 pack. These were either frozen or flash sterilized and canned until use. Grain elevator dust samples were collected from bin toppings, add back chutes, and dust collector tank discharges in Superior, Wisconsin, and were stored at room temperature. Elevators sampled include Continental, Elevator M, Farmers Union, ADM, and Globe facilities. Grain dust samples whose particle size distribution appeared grossly heterogeneous (e.g., wheat dust) or highly aggregated (e.g., sunflower seed dust) were ground in a Wiley mill to pass a 1-mm screen prior to analysis. Portions of each process vegetable waste sample were freeze-dried and also Wiley milled to pass a 1-mm screen prior to analysis.

Moisture contents of grain dust samples were determined by the gravimetric method (Blondin and Green, 1970). Hexose/pentose ratios were determined by spectrophotometry (Scott, 1976). Lignin contents were determined by the spectrophotometric acetyl bromide method (Morrison, 1972). Starch bioconversion was carried out with alpha-amylase and amyloglucosidase according to procedures outlined in the technical information bulletins of the respective enzymes (Biocon [U.S.] Inc., 1981). Bioconversion of cellulose was carried out at 45°C for 48 hours in the presence of 0.5 percent (w/v) cellulase enzyme complex from *Trichoderma viride* (now *T. reesei*). The preparation used was obtained from the Enzyme Products Division of Miles Laboratories. Substrate concentrations were set at 4 to 5 percent (w/v). Fermentations were carried out at 30°C with distillers active dry yeast (*Saccharomyces cerevisiae*) obtained from Biocon (U.S.) Inc. Percent alcohol in the distillates was determined through the use of alcohol dehydrogenase and nicotinamide adenine dinucleotide (Bonnichsen and Theorell, 1951) or by specific gravity measurements.

Biomass Waste Origin and Inventory

The two biomass waste forms evaluated have a long history of embarassment to the respective waste-generating industries. Grain and seed dust in suspension in air is an excellent fuel which has been likened to gunpowder and is claimed to be responsible for many elevator explosions. As the industry responds to this hazard and modifies its practices in scheduled compliance with Federal Clean Air Act standards, each season witnesses the collection of greater quantities of grain dust at elevator facilities. This cleanup represents a severe economic loss to the elevator industry because of the high cost of air scrubbing equipment and poor marketability of the collected dust.

Most vegetable processing byproducts also have negligible economic value. In Wisconsin some waste solids from canneries processing vegetable crops are given away to farmers willing to collect and transport them for use as hog feed. The remainder must be dumped in landfill sites, a practice which is frowned upon by the Wisconsin Department of Natural Resources. The voluminous effluent streams from canneries represent high B.O.D. sugar solutions which cannot be released to surface waters and must therefore be spray irrigated on rented farmland or processed at high expense through private or municipal treatment plants. Accordingly, the vegetable processing industry in Wisconsin spends several millions of dollars annually to dispose of cannery effluent and solid wastes in a manner which will comply with environmental standards.

Grain and seed dust originates from constant abrasion of intact grain and seed during the high-speed handling required to move the commodities efficiently through the elevator facilities. Estimates of the amount of grain dust handled and collected in port elevators vary significantly. The picture is further clouded by the industry-wide trend to collect more and more dust as additional air scrubbing equipment is installed toward compliance with Clean Air Act standards. A high end limiting estimate of 2.6 percent dust per weight of grain or seed has recently been proposed (Schnake, 1981). Table 1 contains a summary, based on this estimate, of the annual elevator grain dust tonnage for the grain and seed storage facilities in the Superior-Duluth area. The data show that presently a maximum of approximately 232,000 tons of grain and seed dust is potentially collectable each year at these facilities. A more accurate estimate of this figure will be forthcoming as the Superior Harbor Commission plans to inventory dust collector discharges during the 1981 transshipment season (Olson, 1981). Scheduled new elevator construction and elimination of the embargo on the export of grain to Russia is likely substantially to increase the throughput of the Superior-Duluth grain elevators and hence the amount of grain dust generated.

TABLE 1. Estimated annual quantities of grain and seed dust at Superior-Duluth export elevators.

Commodity	*1980 transshipment tonnage*[a]	*Maximum estimated dust tonnage*[b]
Wheat	5,096,000	132,500
Corn	1,174,000	30,520
Sunflower seed	1,377,000	35,800
Other[c]	1,270,000	33,020
Total	8,917,000	231,840

[a] Port of Duluth-Superior 1980 Tonnage Report No. 9.
[b] Assumed to be 2.6 percent of transshipped grain and seed (Schnake, 1981).
[c] Includes barley, flax seed, oats, rye, and soybean.

TABLE 2. Estimated annual quantities of process vegetable waste.

Vegetable crop	*Input tonnage*[a]	*Process waste* %	*Process waste* Tons
Sweet corn	513,520	50[b]	256,760
Potato	259,875[c,d]	55[e]	142,930
Snap bean	211,184	21[f]	44,439
Green pea	153,670	22[b]	33,807
Beat	77,800	50[b]	38,900
Carrot	45,000[g]	44[b]	19,800
Lima bean	4,900	14[f]	686
Total	1,256,949		537,232

[a] Wisconsin Agricultural Statistics Bulletin, "Summary of 1980 Process Vegetable Crops."
[b] According to Wisconsin Canners and Freezers Association.
[c] 1979 Wisconsin Agricultural Statistics, Wisconsin Agricultural Service.
[d] Assumes that only 30 percent of harvested crop was processed.
[e] Personal communication from D. H. Penly, Oconomowoc Canning Co.
[f] Cooper (1976).
[g] Assumes that only 80 percent of harvested crop was processed.

Byproduct wastes from vegetable processing originate in canneries in two main forms: discrete solids and screened effluent. Discrete solids include leaves, trimmings, stems, peels, pods, husks, cobs, silk, and defective processed vegetables. Screened effluent contains leached starches and sugars carried in suspension or solution through 20-mesh screens. The vast volumes of screened effluent flow originate from water input at various stations during vegetable processing. Depending on the vegetable source, water is added at stations for washing, husking, desilking, blanching, cutting, peeling, slicing, clipping, screening, grading and inspection. Table 2 contains a summary of the total annual process byproducts wastes generated in Wisconsin canneries. The data include both discrete and screened effluent wastes and in general reflect the total weight decrement between canned product and vegetable crop input. Based on a total of approximately 537,000 tons of byproducts wastes, the weighted average byproducts wastes tonnage in Wisconsin canning industry is about 43 percent of the input crop.

ANALYSIS AND ALCOHOL POTENTIAL OF GRAIN AND SEED DUST

A previous study (Martin, 1978) of the composition of grain dust suggested that dust from specific grains have characteristics similar to the grain from which it came. Thus wheat and corn dust were reported to contain 80.2 percent and 96 percent, respectively, of the carbohydrate of intact wheat and corn. However, the fiber content of wheat dust (16.4 percent) was about 5.5 times higher than that found in intact wheat (3.0 percent), while that of corn dust (7.4 percent) was only thrice that found in intact corn (2.5 percent). These observations suggest that wheat dust may contain much more lignin and hemicellulose than intact wheat. If this is so, an appreciable fraction of the total carbohydrate of wheat dust might be "nonfermentable" five carbon sugars (pentoses) and lignocellulose complex. Since wheat dust is by far the major waste in the Superior-Duluth facilities (see Table 1), it was important to examine this question. The data shown in Table 3 clearly establish the high pentosan content of wheat dust. While the pentose fraction derived from intact wheat accounts for only 14.5 percent of the total carbohydrate, that from wheat dust accounts for 42 percent. Thus, while the total carbohydrate content of wheat dust was 71.3 percent of intact wheat, the readily fermentable carbohydrate (hexose) content was only 48.5 percent of that of intact wheat. The significant increase in lignin content (from 1.1 to 8.7 percent), an indicator of structural carbohydrate (hemicellulose/pentosan), found in wheat dust is in agreement with these findings.

Corn dust is remarkably different, having characteristics closely related to intact corn (Table 3). Commodities other than wheat, corn, and sunflower seed dust have not yet been examined by us. The values quoted in Table 3 for these commodities are assumed

TABLE 3. Analysis of elevator grain and seed dust.[a]

Commodity	*% total carbohydrate*	*% hexose*	*% pentose*	*% lignin*	*% moisture*
Wheat dust	44.2(5)	25.7(5)	18.5(5)	8.7(1)	7.65(2)
Wheat	62	53	9	1.1	nd[b]
Corn dust	70(3)	58.3(3)	11.7(3)	3.4(1)	9.3(2)
Corn	69	62	7	1.9	nd
Sunflower seed dust	36.3(3)	23(3)	13.3(3)	5.4(1)	8.0(2)
Other[c]	50	40	10	nd	nd

[a] The grain and seed dust are averages for the number of samples analyzed which is included in parentheses after each value.
[b] nd = not determined.
[c] Based in part on the data of Martin (1978).

TABLE 4. Alcohol potential of grain and seed dust.[a]

	Gallons of 200 proof alcohol					
Dust commodity	*Hexose fermentable*		*Pentose fermentable*		*Total fermentable*	
	Per ton	*Total*	*Per ton*	*Total*	*Per ton*	*Total*
Wheat	44.2	5,857,000	22.2	2,942,000	66.4	8,799,000
Corn	100.2	3,060,000	14.0	429,000	114.2	3,489,000
Sunflower	39.5	1,416,000	15.9	571,000	55.4	1,987,000
Other	68.8	2,272,000	12.0	396,000	80.8	2,668,000
Total	—	12,605,000	—	4,338,000	—	16,943,000
Average	54.4	—	18.7	—	73.1	—

[a] Based on analytical data of Table 3. Conversion factors used were (1) 172 gallons of alcohol per ton of starch (hexose) and (2) 120 gallons of alcohol per ton pentose assuming fermentation by a pentose utilizing organism such as *F. oxysporum* (Batter and Wilke, 1977).

TABLE 5. Carbohydrate content of process vegetable wastes.[a]

Vegetable byproducts	*Extractable CBH*[b] %	*Extractable CBH*[b] *Tons*	*Crude-fiber CBH* %	*Crude-fiber CBH* *Tons*
Sweet corn ...	16.4	42,109	8.0	20,541
Potato	15.8	22,583	1.4	2,001
Snap bean ...	6.1	2,705	1.0	444
Green pea ...	12.4	4,192	2.0	676
Beat	8.0	3,112	4.0	1,556
Carrot	7.0	1,386	2.5	495
Lima bean ..	20.3	139	1.0	7
Total		76,226		25,720

[a] Based on data of Table 2 and that of Cooper (1976).
[b] CBH = carbohydrate.

TABLE 6. Hexose/pentose analysis of extractable carbohydrate from process vegetable wastes.[a]

Vegetable byproducts	*Hexose* %	*Hexose* *Tons*	*Pentose* %	*Pentose* *Tons*
Sweet corn ..	98.6	41,519	1.4	590
Potato	86.9	19,625	13.1	2,958
Snap bean ...	85.7	2,318	14.3	387
Green pea ...	86.2	3,614	13.8	578
Beet	89.6	2,788	10.4	324
Carrot	86.5	1,199	13.5	187
Lima bean[b] ..	90	125	10	14
Total		71,188		5,038

[a] Based on analyses of data compiled in Table 5.
[b] Estimated.

TABLE 7. Hexose/pentose analysis of crude-fiber carbohydrate from process vegetable wastes.[a]

Vegetable byproducts	*Hexose* %	*Hexose* *Tons*	*Pentose* %	*Pentose* *Tons*
Sweet corn ...	63.9	13,126	36.1	7,415
Potato[b]	75	1,501	25	500
Snap bean ...	75.8	337	24.2	107
Green pea ...	72.1	487	27.9	189
Beet	71	1,105	29	451
Carrot	70.5	349	29.5	146
Lima bean[b] ...	70	5	30	2
Total		16,910		8,810

[a] Based on analyses of data compiled in Table 5.
[b] Estimated.

values based in part on previous data (Martin, 1978).

Estimates of the alcohol potential of grain and seed dust are contained in Table 4. The information is presented in three different formats representing (1) the alcohol potential based on standard fermentation technology using *S. cerevisiae,* which ferments only hexoses; (2) the incremental alcohol potential which would be obtained by fermentation with pentose utilizing microorganisms (e.g., *Fusarium oxysporum*) and (3) the theoretical total alcohol potential assuming fermentation of both hexose and pentose sugars. Since the probable input to fermentation facilities proposed for the Superior-Duluth area would be a proportioned mixture of dust from several grain and seed sources, the weighted average alcohol potential per ton is the most significant projection. Standard fermentation practices would be expected to yield an average of 54.4 gallons of 200 proof alcohol per ton of mixed grain and seed dust. This value can be compared with an industry-wide average value of 79 gallons per ton from several intact grain commodities (Mandeville, 1980). Improved technology aimed at complete hexose/pentose fermentation would raise this projection to 73.1 gallons per ton, very close to the yield expected from the parent grain and seed mixture.

Analysis and Alcohol Potential of Process Vegetable Wastes

If the discrete solids from vegetable wastes are pressed hydraulically an expressate, rich in soluble sugars, is obtained. The pressed residue contains the bulk of the crude fiber carbohydrate (cellulose and hemicellulose) wastes while the bulk of the soluble or extractable carbohydrate wastes is present in a mixture of the screened effluent and expressate. Estimates of the percent distribution of extractable and crude-fiber carbohydrate are available for each class of vegetable byproducts wastes. Table 5 shows a compilation of these estimates applied to the byproducts yields described in Table 2. These calculations provide a breakdown of the net extractable and crude fiber carbohydrate content for each of the vegetable crop byproduct wastes encountered in the Wisconsin canning industry. Thus, an annual total of approximately 76,000 tons of readily bioconvertible extractable carbohydrate is available from Wisconsin canneries, with an additional 26,000 tons potentially available depending on the efficiency and cost-effectiveness of bioconversion. Already the lower amounts of carbohydrate would suffice to produce a theoretical maximum of approximately 11.6 million gallons of 200 proof alcohol.

Since the hexose/pentose ratio of wastes determines in large measure the ultimate alcohol yield, each available vegetable byproducts sample was submitted to hexose/pentose analysis. The results for extractable and crude-fiber carbohydrate are described in Tables 6 and 7. As expected, crude-fiber carbohydrate contains more pentose (34 percent) than does extractable carbohydrate (6.6 percent). Surprisingly, extractable carbohydrate does contain an appreciable pentose component, but this is not expected to affect greatly the alcohol potential of this vegetable byproducts fraction. More importantly, the fermentable sugar (hexose) content data allow projections to be made with greater fidelity of alcohol yield obtainable by standard fermentation technology.

Estimates of the alcohol potential of process vegetable byproducts wastes are compiled in Tables 8 and 9 for extractable and crude-fiber carbohydrate. Again, the estimates are presented in three ways describing the alcohol potential based on (1) hexose fermentable sugars, (2) pentose fermentable sugars, and (3) total fermentable sugars.

In summary, standard fermentation practices applied to Wisconsin's vegetable byproducts wastes could be used to produce approximately 11 million gallons of 200 proof alcohol. Effective saccharification of cellulosics coupled to standard fermentation practices could generate an additional 2.9 million gallons for a total of 13.9 million gallons. Finally, improved fermentation technology aimed at the co-utilization of pentose sugars could produce an additional 1.66 million gallons for a grand total from vegetable byproducts wastes of 15.56 million gallons.

It is important to point out at this juncture that all of the estimates given assume

TABLE 8. Alcohol potential of extractable carbohydrate from process vegetable wastes.[a]

Vegetable byproducts	*Gallons of 200 proof alcohol* Hexose fermentation	Pentose fermentation	Total fermentation
Sweet corn	6,435,000	70,800	6,505,800
Potato	3,042,000	354,960	3,396,960
Snap bean	359,300	46,440	405,740
Green pea	560,200	69,360	629,560
Beet	432,100	38,880	470,980
Carrot	185,800	22,440	208,240
Lima bean	19,400	1,680	21,080
Total	11,033,800	604,560	11,638,360

[a] Based on data compiled in Table 6 and the following bioconversion factors: 155 gallons per ton for hexose fermentation and 120 gallons per ton for pentose fermentation.

TABLE 9. Alcohol potential of crude-fiber carbohydrate from process vegetable wastes.[a]

Vegetable byproducts	*Gallons of 200 proof alcohol* Hexose fermentation	Pentose fermentation	Total fermentation
Sweet corn	2,258,000	889,800	3,147,800
Potato	258,200	60,000	318,200
Snap bean	57,960	12,840	70,800
Green pea	83,760	22,680	106,440
Beet	190,100	54,120	244,220
Carrot	60,030	17,520	77,550
Lima bean	860	240	1,100
Total	2,908,910	1,057,200	3,966,110

[a] Based on data compiled in Table 7 and the following bioconversion factors: 172 gallons per ton for hexose fermentation and 120 gallons per ton for pentose fermentation.

theoretical yields which are seldom encountered at industrial levels. Cumulative bioconversion losses are routinely encountered during starch and cellulose saccharification as well as fermentation with *S. cerevesiae*. Losses encountered during mashing of grains are generally related to inefficient grain processing (grinding). This is unlikely to be a problem with grain and seed dust since the particle size distribution of the dust is considerably smaller than that of traditional ground grain input to fermentation vats (Martin, 1976). However, the trade-off with grain and seed dust comes from its higher level of structural carbohydrate, which may restrict access to saccharifying enzymes of a portion of the hexoses (Harkin, 1973).

Losses are also encountered during fermentation because a portion of the sugars is consumed in growth of the yeast necessary for the alcoholic fermentation, and products other than ethyl alcohol and carbon dioxide are produced in small quantities during fermentation. Finally, firm data are not yet available on the efficiency of recovery of dilute sugars from the extractable carbohydrate fraction of vegetable byproducts and on the efficiency of cellulosics saccharification. It is difficult at this time to put a precise figure on these losses; somewhere in the range of 8 to 12 percent of the overall quantity of wastes available from the two major sources under consideration seems a reasonable estimate. Some of these imponderables will be discussed in more detail in the following section.

Production Considerations

Since the bulk of the alcohol potential of cannery wastes and grain and seed wastes is derivable by traditional bioconversion technology, in the discussion of production considerations emphasis must be placed on readily fermentable feedstock fractions. Exploratory studies aimed at bioconversion of more intractable wastes (e.g., cannery wastes crude-fiber carbohydrate and wheat dust

Table 10. Wisconsin process vegetable wastes expressate volumes and carbohydrate concentrations.

Vegetable byproducts	*Carbohydrate in expressate (%)*	*Effluent volume[a] gallons × 1000*	*Volume normalized to 20 percent sugar* Factor	*Volume normalized to 20 percent sugar* gallons × 1000
Corn husk[b]	11.0	14,071[c]	1.82	7,731
Corn stream	2.68	314,626[d]	7.46	42,175
Potato	1.92	278,759	10.4	26,804
Snap bean	2.0	32,054	10.0	3,205
Green pea	4.45[e]	22,326	4.49	4,972
Beet	2.9	25,433	6.90	3,686
Carrot	2.52	13,035	7.94	1,642
Lima bean	2.0[f]	1,647	10.0	165
Total	—	701,951	—	90,380
Average	2.58	—	7.75	—

[a] Calculated by dividing the total extractable carbohydrate tonnage of Table 5 by the percent concentration of carbohydrate in the expressate, followed by multiplication of this number by 23,700.
[b] Includes husks, cobs, and silk cuttings.
[c] This source accounts for 6,531 tons of carbohydrate (Penly, 1981).
[d] Based on the estimate of carbohydrate remaining after removal of 6,531 tons.
[e] Based on dietetic pea pack expressate.
[f] Estimated.

pentosans) have been performed and will be described in future reports.

Cannery Wastes Extractable Carbohydrate

The major drawback to immediate utilization of extractable carbohydrate from process vegetable byproducts wastes is their excessive dilution, as can be inferred from B.O.D. values of cannery effluents (Weckel et al., 1968). While the precise carbohydrate concentrations of the screened effluents are not yet known, those of expressates have been determined and the data are compiled in Table 10. Since the screened effluents were formerly in solution equilibrium with the expressate solutions derived from the discrete wastes, the carbohydrate concentration in the former is likely less than that found in the expressates. However, for purposes of production considerations, the concentration of total extractable carbohydrate is assumed to be identical to that of the expressate solutions.[1] Except for expressates from corn and husk cuttings, the carbohydrate concentrations fall in the range of 1.92 to 4.45 percent (Table 10), values too low for efficient fermentation and subsequent alcohol recovery. Ideally, input sugar concentrations for fermentation should be in the range of 15 to 20 percent. Therefore, the problem is to concentrate at least 702 million gallons of process effluent soluble sugars containing an average of 2.58 percent by weight of fermentable sugar to a final concentration of at least 15 percent, preferably 20 percent, and a final volume of approximately 90 million gallons. To avoid excessive storage and transportation of the diluted stream, this task must be performed on site, within the span of the canning season (about 122 calendar days), and at a cost not to exceed 6¢ per pound of sugar for the concentrate to remain competitive with other fermentation feedstocks (Gregor, 1979).

For several years dilute sugar streams have been economically concentrated to 25 to 30 percent sugar by candy manufacturers in the U.S.A. and elsewhere, using commercially available reverse osmosis equipment (Spatz, 1974). Recent versions of such equipment have been in use for several months in different locations for the concentration of lactose from whey, for the concentration of beet sugars, and for the purification of water from low B.O.D. corn and potato waste streams (Friedlander, 1981). No significant membrane fouling problems have been encountered in these applications and routine membrane cleaning with detergents has proven an effective means of maintaining full operating efficiency. Thus reverse osmosis technology seems eminently applicable for concentrating vegetable process effluent soluble sugars to fermentable levels.

Economic analysis of unit costs suggests a favorable outlook for commercialization within the canning industry of the large-scale production of process effluent soluble sugar concentrates for fermentation feedstock. While sufficient data are not yet available for an in-depth analysis, the introduction of a few assumptions allows a reasonable estimate to be made of unit costs; these are summarized in Table 11. A commercial re-

TABLE 11. Cost analysis summary of process effluent soluble sugar concentration by reverse osmosis.

Item	*Contribution to annual costs*	*Cents per pound sugar*
A. Fixed costs		
Reverse osmosis equipment	$1,715,000	1.2
Membrane replacement	600,000	0.4
Stainless steel storage	962,000	0.6
Prefiltration equipment	600,000	0.4
Subtotal	$3,877,000	2.6
B. Operating costs		
Power	$ 300,000	0.2
Maintenance	200,000	0.13
RO membrane cleaner	239,000	0.16
Subtotal	$ 739,000	0.49
NET	$4,316,120	3.09

verse osmosis (RO) unit with a molecular weight cutoff limit of 300 would retain the bulk of the extractable carbohydrate. Such a system, operating for 20 hours per day at 400 psi, could process 14.35 million gallons of cannery effluent per season per unit (Friedlander, 1981). Thus a total of 49 units would be required to process approximately 702 million gallons of cannery effluent produced statewide. At a cost of $175,000.00 per unit, the total capital cost for RO equipment would be $8,575,000.00. If amortized over 5 years, the contribution to fixed costs would therefore be $1,715,000.00 per year. Since the useful life of the membranes is estimated at 2 to 3 years of continuous service, membrane replacement costs do not enter into the fixed costs during the period of equipment amortization because the canneries operate for only approximately ⅓ of the year. Thereafter, with membrane replacement every 6 calendar years, the costs should average only $12,200.00 per year per unit for a total annual contribution to fixed costs of $600,000.00.

On-site stainless steel equipment for storage of 2 to 3 days' supply of dilute effluent and concentrate would require an investment of approximately $9,620,000.00. Storage tanks are generally amortized over a long period of time; the annual contribution to fixed costs during a ten-year amortization period would be $962,000.00. Pre-reverse osmosis filtration equipment (e.g., a "Shriver" filter press or continuous discharge centrifuges and sterile filtration cartridges) would be expected to add an additional $3,000,000.00 which if amortized over a five-year period, would contribute $600,000.00 to the annual fixed costs estimate. The total statewide annual contribution to fixed costs would therefore be $3,877,000.00

The operating costs estimates compiled in Table 11 are all based on published estimates (Spatz, 1974) derived from the use of the same equipment used to estimate fixed costs. The figures quoted include both RO and prefiltration associated labor, maintenance, power, and chemical costs. The net annual operating costs amount to $739,000.00 for total statewide annual production cost estimate of $4,616,000.00. Since these costs would cover the production of approximately 76,226 tons of sugar concentrate, the production cost per pound of sugar would amount to approximately 3¢, a value well below the 6¢ per pound limit arbitrarily imposed above for cost-effective reasons. At 6¢ per pound of sugar, the feedstock cost contribution to 200 proof alcohol production is approximately 77¢ per gallon. Since production costs themselves (fermentation and distillation) are in the range of 35 to 45¢ per gallon depending on the value and marketability of distillers by-products, the net production costs for 200 proof alcohol would be approximately $1.17 per gallon, a figure well within the competitive range of gasoline costs today. These figures can be compared with a value of $1.29 for the feedstock share contribution alone of 200 proof alcohol produced from today's cash market grains. The 3¢ per pound difference between our estimate of sugar concentrate production cost and competitive upper limit creates flexibility to absorb other costs (e.g., equipment housing, transportation, syrup production option, incomplete membrane rejection of sugars, shortened membrane life, putrefaction losses, saccharification requirements, etc.) for which sufficient data are not yet available to derive reasonable estimates.

Canneries have two options to use or market their sugar concentrates. First, to avoid storage of 90 million gallons of sugar concentrate, the canneries could sell their fresh concentrates to nearby alcohol producers. The approximately 40.5 million gallons per year of fermentation/distillation capacity expected to be on line in Wisconsin by the end of 1982 (Plaza, 1981) could utilize all of the sugar concentrate from Wisconsin's canneries. Distilleries are presently located in Trempealeau, Marathon, Lincoln, Brown, Juneau, Fond du Lac, Columbia, Dane, Lafayette, Rock, and Walworth counties at sites which literally surround the state's major vegetable processing facilities. By operating for approximately one-third of the year with cannery sugar concentrates as inexpensive feedstock, distilleries could significantly reduce their high outlay for cash market grains as fermentation feedstock.

Second, canneries could run the 20 percent sugar concentrate solutions through scraped-surface heat exchanger evaporators to produce a syrup containing about 60 percent sugars. Normally the energy to evaporate approximately 60 million gallons of water to produce a 60 percent sugar syrup would add another 4¢ per pound to the cost of the sugar produced (assuming 4¢ per KW), exclusive of equipment requirements. However, canneries generate vast quantities of waste heat; the application of heat exchanger technology might contribute a major fraction of the heat required to operate scraped-surface evaporators. Three major benefits might accrue: transportation costs would be significantly reduced, storage facilities need not be so large, and the syrup is more amenable to long-term storage.

Also important is the form of the sugars in the extractable carbohydrate: mono-, di-, or trisaccharides are directly utilizable by yeast but polysaccharides are suitable for fermentation only after extensive enzymatic saccharification. Fermentation/distillation analysis of expressates from corn husk and cob cuttings has established that the yield of alcohol without enzymatic saccharification is 86.4 percent of that found after pretreatment with amylase enzyme. Thus, it is likely that the bulk of the process vegetable extractable carbohydrate is directly fermentable.

Recovery of Sugars from Cannery Wastes Crude-fiber Carbohydrate

Crude-fiber carbohydrate consists principally of cellulose, which must be degraded to simple sugars by chemical, microbiological, or enzymatic processes prior to fermentation. Naturally occurring cellulose is mostly associated with lignin which physically restricts access by enzymes or microorganisms to the glycosidic linkages which must be ruptured to generate simple sugars (Harkin, 1973). In general, the more lignin in a lignocellulosic biomass sample, the greater its resistance to enzymatic or microbiological saccharification. Woody lignocellulosics contain 25 to 30 percent lignin and offer the highest degree of resistance to bioconversion (Millett, 1979). Less than 5 percent of the lignocellulosic sugars of woody biomass are released (Humphrey, 1979) through the action of the cellulase enzyme complex from *T. viride* in the absence of expensive pretreatment processes (e.g., ball milling, explosive decompression).

Cannery wastes discrete solids are in general less highly lignified than woody lignocellulosics (Table 12), and consequently more amendable to enzymatic conversion to simple sugars. The mostly highly lignified vegetable byproduct discrete waste encountered was the solids portion of corn husk and cob cuttings. Despite their 9.7 percent lignin, the latter released 78.3 percent of their total carbohydrate in the form of simple sugars after 48 hours hydrolysis with 0.5 percent cellulase enzyme complex from *T. viride.*

TABLE 12. Lignin content and saccharification efficiency of cannery wastes crude-fiber carbohydrate.

Discrete wastes sample	*% lignin*	*% saccharification*[a]
Corn stover	14.4	41.3
Corn husk and cob cuttings	9.7	78.3
Snap bean	3.8	84
Beet	2.4	81.5
Pea	2.3	nd[b]

[a] Saccharification was carried out in the presence of Cellulase TV (Miles) for 48 hours at 45°C and at pH of 4.5. Substrate concentration was set at 4 percent and the enzyme concentration at 0.5 percent.

[b] nd = not determined.

All other cannery discrete wastes samples are less lignified and should afford good or better yields of sugar on cellulose hydrolysis than corn husk and cob cuttings. This is borne out by the saccharification results obtained with snap beans and beet discrete solids wastes.

Data for corn stover are included because this material has a lignin content intermediate between that of cannery wastes solids and that of woody biomass. The sharp decrease in the enzymatic release of simple sugars observed with this sample suggests a major structural impediment to enzymatic attack in going from 9.7 percent to 14.4 percent lignin. While other factors such as cellulose crystallinity and graft copolymerization (Harkin, 1973; Caulfield and Moore, 1974) could be partially responsible for this remarkable transition, the two key features of these data are that all cannery wastes discrete solids examined appear to contain less than 10 percent lignin and all appear to be efficiently degradable to simple sugars in yields greater than 78 percent with extracellular cellulase enzyme complex.

Recovery of fermentable sugars from cannery wastes crude-fiber carbohydrate is therefore a technically feasible endeavor. However, cost effectiveness of such a venture cannot be accurately assessed without additional data. The principal drawback to the use of commercially available cellulase enzyme complex is the long residence time (*circa* 48 hours) at 45°C required for complete conversion and the danger of putrefaction at these temperatures, which could add significantly to the cost of bioconversion. There are two alternatives open to cope with this problem: 1. Use of the thermotolerant cellulase enzyme complex from *Thielavia terrestris* (Tusé et al., 1980), which is active at or near conventional mashing temperatures, to effect a faster rate of cellulose hydrolysis per unit time; or 2. simultaneous enzymatic saccharification with commercially available thermolabile cellulase and fermentation, a strategy similar in concept to the Gulf Process (Emmert and Katzen, 1979). Both of these options are currently under investigation in our laboratory.

Bioconversion of Grain and Seed Dust

The key consideration relative to the bioconversion of grain and seed dust will probably be its market value to the graneries as feedstock for alcohol production. Presently, such wastes are sometimes sold for approximately $11.00 per ton for pelletizing and use as animal feed. This price is only about 10 percent of the market value of intact grain and seed. Because of the severe economic loss incurred in the removal of grain and seed dust, currently U.S. export elevators return some of the collected dust to export grain and seed; this practice lowers the quality of U.S. export commodities and is contrary to the recommendation of U.S. Government regulatory agencies, which have "requested" that grain dust removed not be returned to grain. Diversion of all collected dust to fermentation feedstock requires that a higher unit value than that at present be placed on grain and seed dust wastes.

Critical information required to estimate the potential value of grain and seed dust as fermentation feedstock includes the alcohol yield per ton, the production costs, and the market value of the product (200 proof alcohol). Data on the alcohol potential per ton are contained in Table 4. Since conventional fermentation practices do not currently utilize pentose sugars for the production of alcohol (see however, Batter and Wilke, 1977; Anonymous, 1981a), the most conservative estimate of alcohol potential must be based on the hexose content. On this basis, mixed grain and seed dust currently available from the Superior facilities should yield approximately 54.4 gallons of 200 proof alcohol per ton. Estimates of production costs (Katzen, 1980) for a 10 million gallon per year batch plant processing grain established a base conversion cost of

32.5¢ per gallon, exclusive of feedstock cost but including a distillers byproducts value equivalent to 38.6¢ per gallon. Since the June 15, 1981 price quotations (Anonymous, 1981b) for anhydrous alcohol averaged $1.80 per bulk f.o.b. gallon, the theoretical grain and seed dust value capable of being sustained would be $1.80 less production costs of 32.5¢ per gallon or $1.475 per gallon equivalent. Since each ton of grain and seed dust could be used to produce at least 54.4 gallons of alcohol, the maximum value per ton of feedstock would be $80.24, or 7.3 times the value afforded by diversion to animal feed and approximately 73 percent of the value of the intact commodity. Marketing practices aimed at competitiveness with current gasoline prices (approximately $1.30 per gallon) would reduce the value of $53.04 per ton or still 4.8 times the value afforded by diversion to animal feed. Finally, simultaneous bioconversion of the pentose fraction of grain and seed dust could convey maximum values of $107.80 to $171.30 per ton, respectively, depending on marketing practices. Studies are presently underway to determine the feasibility of pentose co-fermentation.

All of the above estimates are based on the production of anhydrous alcohol for blending to gasohol. Production of wet alcohol for a straight fuel market would be attended by a decrease in production costs, and decrease in alcohol value relative to the anhydrous alcohol market.

Summary

Grain elevator dust and process vegetable byproducts are good examples of economic liabilities which can be converted into assets through conversion to fuel-grade alcohol. The ability of these two biomass waste sources to support a viable fuel-grade alcohol production industry is intimately tied to the elimination of major costly industrial waste disposal problems. The vegetable processing industry in Wisconsin spends several millions of dollars annually to dispose of high B.O.D. cannery effluent and a major portion (greater than 30 percent) of the input crop as solid waste in a manner which will comply with environmental standards. Occupational Safety and Health Act, the requirements of the 1970 Clean Air Act, and the incidence of grain dust explosions are forcing grain elevator facilities to install expensive air scrubbing equipment to collect and dispose of grain and seed dust, currently a near valueless byproduct. Utilization of byproducts from these two sources as fuel-grade alcohol feedstock would therefore attenuate the burdens of waste disposal and regulatory compliance for the affected industries, in addition to sparing fossil fuel.

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NOTE

[1] An inventory of extractable carbohydrate carried out during the early part of the 1981 vegetable pack has thus far revealed two general trends: 1. The total amount of extractable carbohydrate wastes exceeds the estimates described herein by an average of 38 percent; and 2. the weighted average effluent carbohydrate concentration for both the green pea and snap bean pack is less than that of the expressate alone. Thus, while it is theoretically possible to recover more sugar than originally estimated, the reverse osmosis equipment requirements specified in this report are sufficient for the recovery of only 70 percent of projection.

MORAL ASPECTS OF THE ALLOCATION OF PUBLIC HEALTH CARE FUNDS

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When a society decides to devote some portion of its public resources to health care, significant questions about allocation arise. First of all, of course, there is the question of how much of the society's total resources ought to be allocated to health care—as opposed to defense, education, and so forth. That, however, is not the question with which this paper deals. For the purposes of the present inquiry, it will be assumed that the decision about what portion of resources to allocate to health care has already been made. The question here is how the resources made available for health care ought to be allocated to each of several possible areas.

This matter acquires considerable importance from the intimate connection between good health and the good life (as discussed by classical Greek philosophers). Whether one thinks in terms of designing a society in which individuals can achieve something approaching the good life, or in terms of evaluating existing societies with an eye to the individual's chance of attaining the good life in them, the individual's chance of enjoying good health must be taken into consideration. And the individual's chance of enjoying good health in a given society can certainly be affected by the way that public health-care funds are used in that society.

It should be kept clearly in mind that the problem at issue here is *not* that of the proper distribution of expensive medications and scarce medical equipment. That matter has been examined by a number of writers in recent years, and some of the most interesting articles—including Nicholas Rescher's "The Allocation of Exotic Medical Life-saving Therapy"—have recently been reprinted in Ronald Munson's excellent *Intervention and Reflection: Basic Issues in Medical Ethics.*[1] Such discussions, however, are basically concerned with the distribution of resources allocated for the *treatment* of ill health. And this question can be seen as subsidiary to the question at issue in this paper—that of the proper distribution of resources alloted to health care. Treatment is just one of several areas in which health-care funds can be spent, and part of the question to be discussed here is just how much of such funds ought to go for treatment in the first place.

I should like to suggest that by "stepping back" to consider this matter of the allocation of public resources among what must be acknowledged to be competing areas in health care, we may be able to see over the tangles of equipment-and-medication allocation difficulties to discover something of importance for future public policy decisions.

What kind of areas do I have in mind when I speak of competing areas of health care? Treatment is one, prevention is another, and research is a third. I do not mean to suggest that this is the only way in which the field of health care can be subdivided—or that there are no areas of overlap between these areas. I simply believe that for the purposes of discussing how public funds for health care are to be employed, it is important to consider this particular division. As a matter of fact, as will be seen shortly, one of these areas turns out to be of particular importance from a particular moral point of view.

I wish to begin by considering the "history" of a health problem, not as it affects any particular individual, but as it affects a whole society over a long period of time. One could, of course, speak in terms of actual examples, but I believe that the relevant points can be made most clearly in the abstract. Consider, then, some health problem that affects the members of some society. (I use the expression "health problem" because I wish to include functional disorders, injuries, and behavioral problems as well as diseases.) The problem may exist for many generations before anything effective is done about it, simply because the civilization does not have the knowledge or the materials to do anything about it. During this period of the problem's history, which for our purposes can be labelled "Stage One," individuals afflicted suffer—or at least experience discomfort—without recourse. From the point of view of a disease, Stage One is a time of flourishing. With respect to injuries, Stage One represents the period of most serious consequences for the injured parties. And in general, Stage One in the history of a health problem is the worst from the point of view of the individuals affected.

Eventually, if the society in question is fortunate, Stage One comes to an end: someone discovers something that effectively reduces the discomfort associated with the problem. A medicine is found that alleviates the symptoms of the disease, or that accelerates healing of the injury; or therapy is developed to improve the existence of persons with a particular emotional problem. Such developments usher in Stage Two in the history of the health problem—the period of the problem's containment and decline. The disease may continue to survive, but its ravages are reduced. The injuries or congenital defects may still occur, but the severity of their consequences is lessened. In Stage Two the society affected by the problem is fighting back with some success.

The duration of Stage Two is every bit as problematic as that of Stage One. Just as some societies may cease to exist before any effective treatment for certain health problems is found, so other societies may never get beyond Stage Two with respect to certain health problems. There is no guarantee that a particular society will ever go beyond "containing" a particular health problem. But there is always a possibility that the society may at length obtain the information and equipment that will permit it to control the problem so thoroughly that it might as well not exist. It is at this point that the problem can be said to pass into Stage Three of its history.

In Stage Three the problem is completely under control. The disease is entirely prevented—or it is completely cured if it does occur. The physical deformity is entirely repaired. The injury is induced to heal completely, and the emotional disorder is rectified once and for all. The society, in brief, no longer suffers from the problem because the problem has been overcome.

In some societies, people may regard Stage One as the unalterable *status quo* with respect to certain health problems—or even with respect to health problems in general. They may mistakenly assume that suffering caused by disease and deformity is an essential component of human existence. In other societies, people may suppose that certain health problems can be at most controlled, and that a diminution of the associated suffering is the best that can be hoped. They may, in other words, accept Stage Two as the unchangeable *status quo*. In our own civilization, however, by dint of good fortune and good work in recent centuries, we have come to appreciate the possibility of Stage Three. Indeed, with respect to certain health problems, we have actually witnessed the arrival of Stage Three. And we have come to look forward eagerly to its advent with respect to many other health problems.

As a matter of fact, indications are strong that there is literally no limit to the number of health problems that can eventually be ushered into Stage Three of their history. It may prove possible, in the course of time, to bring *all* diseases, both major and minor, under complete control. Colds and VD may become as much a thing of the past as smallpox. We may find sure ways of preventing mental illness. We may learn to regenerate major organs. And it may even become possible to eliminate the disorders associated with aging. We *may* that is, ultimately eliminate health problems altogether. Should this last possibility strike you as entirely without plausibility, may I simply invite you to reflect on the advances in medical knowledge that have been made in the last several hundred years. Is it really very likely that a thousand years from now—barring some untoward development that could stop the advance of knowledge—we will still be plagued by hemorrhoids and hay fever? At the very least, I think it must be admitted that in the light of previous progress in the containment and control of a wide range of health problems, it is entirely possible that Stage Three will come for the vast majority of the problems we know at present. And should new problems arise, there is no special reason to think that they will prove less tractable than those we have already overcome.

In order to appreciate an important ethical issue which arises when the three-stage history of a health problem is taken into consideration in a discussion of the allocation of public health-care resources, it will be necessary to focus on a particular facet of this history—the manner in which the suffering associated with a health problem varies from one stage to another. And in doing this it will be well, at least at the outset, to limit consideration to a hypothetical society in which population size does not vary significantly through the three stages of a problem's history. Assume, if you will, that factors entirely unrelated to the problem in question operate in such a way as to keep the size of the population constant.

Stage One, then, is likely to be that in which health problems occasion the greatest amount of suffering (per unit of time). When there is no effective means of prevention or treatment for a disease, an injury, a congenital deformity, or an emotional illness, it is likely to produce a maximum of pain, discomfort, and sorrow—both for the people directly affected and for those who love, depend upon, or take care of them. There may, of course, be exceptions. Some health problems may prove quickly terminal for the afflicted individual in Stage One and may drag on and on in Stage Two. In such cases, it is possible that the total suffering undergone by a given individual in Stage Two of a particular problem's history might be greater than that undergone by a similarly afflicted individual during Stage One. In general, however, it would seem that, other things being equal, it would be preferable to encounter a health problem in Stage Two rather than in Stage One of its history.

Accordingly, Stage Two can be accurately described as the period in a health problem's history in which it is responsible for the second greatest amount of suffering. Part of the control that people obtain over the problem in Stage Two may be control over the pain it causes to the person directly involved—or it may be of such a nature as to prevent the development of the problem into its most painful phases. To be sure, the original control attained over the problem *may* consist merely in the ability to limit the number of individuals stricken—and the severity of the problem for those who do encounter it. In any event, if one had to choose to live in a society in which a particular health problem *might* be encountered, one would still be well advised to elect the society in which the problem was in Stage Two. If the ravages connected with the problem are not reduced by that society's containment measures, at least the likelihood of having it in the first place may be less because of those measures.

Stage Three, quite naturally, stands out as the period in which a health problem causes virtually no suffering at all. No one dies from the problem; no one suffers extended pain from it; no one is even seriously inconvenienced by it. Most evidently, other things being equal, one should choose to live in the society in which a given health problem is in Stage Three of its history.

The suffering caused by a health problem over the course of its history can be represented as a curve. This curve, which will be referred to as the "total-suffering curve" for a health problem, shows the suffering produced by the problem as a function of time. During Stage One, the curve will typically be high and roughly parallel to the time axis, although there may be cyclic fluctuations. Seasonal diseases may be responsible for more suffering at certain times of the year than at others; congenital birth defects which prove quickly fatal may occasion more suffering at times of the year when more children are born, and certain injuries, with their associated suffering, may cluster around times of the year when certain activities are more popular. On the whole, however, the total suffering curve for a particular health problem will, in the stable-population society under consideration, run more or less parallel to the time axis during Stage One. At the onset of Stage Two, of course, the curve will drop as the total suffering occasioned by the problem is reduced through the development of means of containing the problem. Then, if those containment methods continue to be improved during Stage Two, the curve will slope generally downward. Finally, when Stage Three arrives and the problem is controlled to the point of nonexistence, its total-suffering curve will either level out just above the time axis or will come to coincide with the time axis at the zero suffering level.

(What sort of unit might be involved if the total-suffering function for a particular health problem were to be expressed precisely? The time could be measured in, say, days from an arbitrary point in time; but what about the suffering? Intuitively, the notion of the total amount of suffering caused by a problem is nonproblematic: for a given time, the more people that are suffering from the problem, and the more intensely they are suffering, the more total suffering there is. How this might actually be measured is another matter. Perhaps it will one day be possible to measure electrical activity in the brain that correlates with suffering—and to use *that* as a measure of the suffering experienced by the individual in question. Short of this, one might think in terms of something like "unpleasant minutes per day." Of course, one ought to make adjustments for the difference between really awful minutes and merely uncomfortable minutes caused by a health problem; but even if this were not done, one could obtain a quantitative indication of the suffering caused by a problem each day by adding up all the unpleasant minutes lived through by different people affected that day. Note that if two people suffered during the same minute, that would make *two* unpleasant minutes experienced for that day.)

Naturally, as the individual total-suffering curves for different health problems in a society "zero out," the curve representing the grand total of *all* suffering in that society will tend downward—so that, other factors being equal, it will become lower and lower as health problems move into Stage Three of their individual histories. And that, of course, is something consummately to be desired. The general notion of social progress is closely bound up with the idea of successive reductions in the height of the grand-total-suffering curve. As generally conceived, the ideal society—even if it is only a sort of Platonic limit to be approached but never reached—would have a grand-total-suffering curve running flat at zero.

It is at this point that the problem for policy makers entrusted with the allocation of public health-care funds becomes apparent. The society has, after all, other things to which it is going to devote part of its resources, so the funds available for all health-care activities are limited. The result is that certain of those activities will have to be restricted at the expense of others. And the problem is that the allocation of public resources to certain areas of health care appears likely to give better results, in terms of reduction of the total suffering associated with a health problem, than would the allocation of those funds to other areas of health care.

It should be evident that there is no point in discussing the allocation of public funds for health care during Stage One of a problem's history. During Stage One, either no funds at all are provided for the alleviation of the problem or else whatever resources are made available are expended in such a way that they produce no results at all. Perhaps time is devoted to incantations that have no effect at all on the health problem. Or perhaps money is spent on useless medications or fruitless therapy. In any case, no progress is made against the problem. In Stages Two and Three, on the other hand, the expenditure of resources on health problems does produce results; so it is here that the question of the proper allocation of public health-care resources arises.

In particular, the question is most pressing during Stage Two of the history of a health problem. In Stage Three, after all, the knowledge and material for complete control of the problem are at hand; and available resources are directed toward their application. (This is not to say, of course, that public resources will be sufficient for the continuing complete control of all health problems that can be controlled. Some problems may, under conditions of scarcity, slip back from Stage Three into Stage Two.) During Stage Two, however, a decision must be made as to what proportion of the available resources will be used for treatment of those already afflicted by a particular health problem, what proportion will be allocated for procedures designed to keep others from becoming afflicted, and what part will be reserved for research designed to move the problem into Stage Three of its history.

The effect of allocating public health-care funds to each of these three areas deserves careful attention. But let us, for the sake of clarity, begin by considering how the total-suffering curve for a particular health problem might behave if no public funds at all were allocated to *any* of the three. Suppose, that is, that all treatment, prevention, and research are left to the private means of individuals and organizations. It is, of course, safe to suppose that private resources will be expended in these areas. Most individuals, if they realize that effective means of prevention or treatment are available for a particular health problem, will choose to allocate some part of their own funds to these ends. And since people tend to place a high value on their own health and that of their loved ones, they may in fact be willing to allocate a fairly large part of their income or assets to treatment and prevention. This alone will often insure that the total suffering associated with a health problem will be kept fairly low in Stage Two. Moreover, if no public funds are available for prevention or treatment, private groups may organize for the express purpose of providing such funds. With respect to research, on the other hand, it may be *only* organizations (commercial or otherwise) that finance research activities when no public funding is forthcoming. Few individuals have the knowledge, funds, and inclination to do research on their own. It is important to realize, however, that research *can* be done—and the end of Stage Two brought about—without the use of public funds at all. It is unlikely, however, that under such conditions Stage Two will end as soon as it would if public funds were available.

Let us now consider the likely effect on the total-suffering curve for a particular health problem if public resources are alloted for dealing with that problem. Suppose, to begin with, that in Stage Two of the history of a particular health problem, public health-care funds are available and are concentrated in the area of prevention. In the case of disease, this might mean that most available funds would be earmarked for eradication of environmental conditions known to contribute to the spread of the disease and for the manufacture and administration of whatever immunizing agents might be known. Few if any public funds would be set aside for treatment of those who, in spite of the preventive measures, contracted the disease. And few public funds if any would be used for research into ways of eliminating the disease altogether. In the case of a type of injury, the prevention-centered approach would mean that available public resources would go toward avoiding injuries of that sort in the first place, through the use of existing techniques. Society's resources would not, in general, be used for the treatment of those who sustained such injuries—nor for research into new ways of preventing them or new ways of repairing the damage.

Because of the preventive measures in effect under this approach, the total-suffering curve for a particular health problem would be substantially lower during Stage Two than it would be without public funds. The definite integral of the total-suffering function for Stage Two, that is, would be smaller under this approach. Although no public resources were devoted to treatment, the mere fact that many fewer people would have the problem means that there would be less overall suffering. (The overall total of "unpleasant minutes" for the entirety of Stage Two would be less.)

The prevention-centered approach, however, has two saliently unattractive features. One, of course, is that members of the society are left more or less to fend for themselves when they encounter a health problem. The frequency of such encounters may indeed be drastically reduced by the publicly funded measures of prevention. There may be, in comparison either to Stage One or to Stage Two without public funds, a greatly reduced likelihood of contracting a particular handicap, or developing a given type of emotional problem. But for those who *do* have health problems in spite of the preventive measures in effect, the lack of public assistance may be painful. If they can obtain treatment through the private channels of the marketplace, they may have no cause for concern. But if treatment is unavailable —either because of cost or because effective methods have simply not been developed—their chances of completing a good life (again, in the classical Greek sense of that phrase) may be significantly diminished.

The other outstandingly unattractive feature of the prevention-centered approach is that, for any given health problem, Stage Three cannot be expected to arrive any sooner than it would if no public funds were allocated to the problem at all. It is most likely that the advance of knowledge relevant to the ultimate solution of the problem will be much slower in the absence of public resources for research than if they were available. True, advances may be achieved by organizations or individuals operating with their own means, but it is unlikely that such advances will come as soon without public funding for relevant research.

The upshot of this last point is absolutely crucial. Under a prevention-centered approach, the total-suffering curve for a given health problem will not "zero out" as soon as it would if public funds were alloted to research. More lives will be touched by the problem, and some lives will be touched by it more often. As long as Stage Two lasts, even those individuals who are not afflicted by the problem themselves run the risk of having their lives repeatedly saddened by the affiliction of people they love. Advances in knowledge are essential if the total-suffering curve for a given problem is to come down from its Stage-Two level to its Stage-Three level. And unless a society benefits serendipitously from a gift of knowledge from some external source, research will be required to obtain that new knowledge.

What if available public resources during Stage Two of a particular health problem's history are devoted primarily to the treatment of those who experience the problem, with little or nothing from public funds going for prevention and research? This could very well be the arrangement under which the greatest overall amount of suffering would occur before the onset of Stage Three. With no publicly funded preventive measures in place, a relatively large proportion of the population might be affected by the problem; and in the absence of publicly financed research, the problem might well continue for a relatively long time—perhaps even indefinitely. To be sure, the concentration of public resources on treatment would reduce the suffering of each afflicted individual. But some unhappiness would still be occasioned by each occurrence of the problem. And the *number* of occurrences could keep the total-suffering curve higher than it would have been if most or all available public resources had gone for prevention. Moreover, the treatment-centered approach does no more than the prevention-centered one to reduce the duration of Stage Two.

For obvious reasons, the approach to public health-care fund allocation that involves concentration on research is not without serious drawbacks either. If few public funds are expended on prevention during Stage Two of a problem's history, the number of occurrences of the problem will be relatively high. It will quite likely be as high as if no public funds were available for health care at all. In addition, the severity of the suffering connected with most health problems will, given the lack of public funds for treatment, be near a maximum. This might not, to be sure, hold for all types of health problems. Without publicly supported treatment, some problems might prove fatal in a relatively short time. And there might, because of this, be less suffering involved in each occurrence than there would have been if publicly funded treatment had been available. For many problems, however, this will not be the case. Lack of public resources for treatment will simply mean greater suffering for each occurrence of the problem.

There is, nevertheless, one point that can be urged in favor of the concentration of public funds in the area of research. And it is far from being an inconsequential point. If the society in question has research capabilities that insure results in proportion to resources allocated, then the concentration of funds in the area of research will have the effect of reducing the length of Stage Two for any given health problem. This will not occur, of course, when a society has only inefficient research systems that simply burn up resources without producing advances in relevant knowledge. But when public resources produce or accelerate successful research, they have the effect of reducing the amount of overall suffering a health problem can cause in a society before it is ushered into Stage Three. In fact, it may well be the research-centered approach that would minimize suffering from a given health problem in the long run. It is true that with minimal public funding for prevention and treatment, the total-suffering curve for a problem would remain high longer than it would under either of the other approaches already considered. But the total-suffering curve would also "zero out" sooner. And because of this, overall suffering during Stage Two could well be less than with either of the other two approaches. (There would be more "unpleasant minutes" per day in the early part of Stage Two, but Stage Two could well come to an earlier conclusion.)

So how are the policy makers who are to allocate public funds for health care to proceed? With respect to any given health problem that has not yet been conquered, they find themselves without any precise knowledge of how long Stage Two is going to last. They do have at their disposal information about the amount of suffering that the problem in question has been causing. They have some idea, that is, of how the total-suffering curve for that problem has behaved in the past, and so they may be able to make a reasonable guess at how the curve will run in the future. Perhaps the total-suffering curve for the health problem in question has been trending down during Stage Two, and perhaps there is no reason to suppose that this trend will change. In that case the allocaters may even be able to predict the time at which Stage Two will end, by projecting the past trend into the future. Or perhaps the total-suffering function has been running roughly parallel to the time axis. In this case, if there is no reason to expect a change, the allocaters can predict that Stage Two will continue indefinitely unless something is done. Similarly, if the total-suffering curve is actually trending *up* during Stage Two, it may be reasonable to expect a continuing increase, with no end to Stage Two in sight.

Obviously, the assumptions that the allocaters make about the future direction of the total-suffering curve will be of the greatest importance for their decision about how to use public health-care funds. If the trend is sharply down, there may be no reason to allocate public funds (or additional public funds) to the area of research. As long as past funding (whether public or private) continues, there may be every reason to suppose that Stage Three will arrive in an acceptably short period of time. On the other hand, if the total suffering curve has been holding steady or moving upward, then there is a strong argument for concentrating public funds—if that has not already been done—in the area of research. The allocaters would presumably like to minimize the overall suffering caused by the health problem during Stage Two of its history, and research may present the only real possibility of bringing Stage Two to an end at all. It is important to remember of course, that the concentration of public health-care funds in the area of research may involve removing public funds from the areas of prevention and treatment. If substantial amounts of public funds have been going into those areas in the past, this diversion may result in a *rise* in the total-suffering curve over the short run. The point, however, is that it can also be expected to lead to the end of Stage Two—and thus to the minimization of overall suffering from the problem during the course of its history.

Will the allocaters actually find many instances of health problems with steady or climbing total-suffering curves in Stage Two? It may very well be that they will. This is rendered much more likely by a fact which has not been taken into account so far—the fact of increasing populations. The previous discussion of the behavior of total-suffering curves under different allocation schemes was conducted with reference to a hypothetical society in which the population remained constant throughout the history of the health problem in question, In reality, allocaters of health-care funds in today's world have to deal with the fact that populations are growing rapidly. And this means, in the case of many health problems, that the total amount of suffering produced is growing too. If a problem affects a certain percentage of the population, then the more people there are, the more suffering (the more "unpleasant minutes") there will be. The health problem that had a nearly flat total-suffering curve in a society of constant size would have a rising total-suffering curve in a society with an increasing population. In times of rapidly increasing population, research concentration of public funds for certain health problems may be urgently required if overall suffering from those problems is to be kept to a minimum—or indeed to any finite amount.

(And what about approaches to the allocation of public health-care funds that would involve different "mixes" of prevention, treatment, and research? It might, in fact, be the case that some such "hybrid" approach to funding in connection with a particular problem would be the one that would turn out to minimize overall suffering. Ideally, what the allocaters want, we may presume, is the allocation scheme that will produce the total-suffering function with the smallest definite integral for Stage Two of the problem's history. Unfortunately, it may be difficult for the allocaters to predict with any accuracy what functions would result from different allocation "mixes." When this is the case, the relative dependability of research as a means of ultimately bringing down the total-suffering curve may argue strongly for the research-oriented approach.)

Thus—at least with respect to certain health problems—the allocaters of public health-care funds may have strong reasons for concentrating those funds in the area of research. This conclusion, however, immediately suggests certain ethical complications. On the one hand, from the point of view of (act) utilitarianism, the overall reduction in suffering likely to be obtained by favoring research would seem to make it *morally* incumbent upon the policy makers to allocate the funds in this way. On the other hand, numerous deontological theories of morality which recognize the existence of an independent principle of justice (in the sense of fair, impartial, or even-handed treatment) would appear to have difficulties with certain aspects of the research-centered allocation scheme.

Consider, to begin with, the utilitarian position, which declares the morally preferable course of action to be that which will, in the long run, keep the overall sum of happiness as far ahead of the overall sum of unhappiness as possible. Its analysis of the matters under consideration here is quite straightforward. If overall suffering from a particular health problem can only be minimized by a concentration of public health-care funds in the area of research, then that is what ought morally to be done. A careful utilitarian would have to inquire, of course, as to whether such a use of the funds might not cause enough suffering in some other area (unrelated to the health problem) to offset the suffering saved by the research concentration. This might rarely be the case. (An unexpected side effect of the research might, for example, be the development by one of the companies involved of a substance which would enable it to enslave the society.) I cannot, however, think of reasons for supposing this to be the case in general. Furthermore, it is highly likely that research funded in connection with one health problem will from time to time have results applicable to the elimination of other health problems. From the utilitarian point of view, this possibility of an additional contribution to the reduction of suffering in general certainly strengthens the moral case for the concentration of public health-care funds in the area of research. In short, with respect to many health problems, a utilitarian will want to hear very strong arguments if someone suggests that available public funding ought *not* to go for research.

Are there, in general, strong arguments against the sort of research concentration in question here? The answer would seem to be that there are not any that would impress a utilitarian. If, however, the ethical analysis of the matter at hand is conducted from the point of view of a deontological moral theory, then there may indeed be a reason for hesitancy about concentrating public health-care funds in the area of research. In particular, there is a possibility that there would be something *unfair* about the allocation of most such funds for this purpose. And on many theories, what is unfair is immoral.

Various nonteleological theories could serve as the basis for this sort of criticism.

What these theories have in common is their belief in the existence of a moral rule against unfair or partial distributions. Because of the existence of this rule, they maintain, unfair or biased distributions are immoral. The theories differ with regard to the origin of the rule: some think of it as existing of itself, independent of the reason or volition of any being; others hold it to be a necessary product of human reason; others believe it to have been laid down by a supreme ruler of the universe; and others think of it as a convention existing through the mutual agreement of a number of individuals. The ontological status of the rule is not, however, of the first importance for the present discussion. The important question here is whether, in fact, this commonly recognized principle of fair distribution *does* rule out the concentration of public health-care funds in the manner discussed.

It is undeniable that the research-centered approach to a health problem would, to a certain extent, sacrifice the interests of individuals afflicted at present to the interests of those who might be similarly afflicted in the future. Would this be unfair? Both the individuals suffering now and those who might suffer in the future are—or would be—interested in being free from discomfort caused by the health problem. And the allocation of funds provided for dealing with a particular health problem can be seen as the distribution of freedom from discomfort. Can it then be fair to spend public funds to benefit future victims at the expense of present victims?

Suppose a choice were made to expend public health-care funds for the benefit of people living in a certain part of the country at the expense of people with the same problem living in another part of the country. Here it would be difficult to claim that the funds were being spent impartially or evenhandedly. If they were being spent for medication, they ought—in the name of fairness—to be spent for medication for people in all parts of the country. And if the funds were insufficient to procure medication for everyone afflicted, then fairness would require that recipients be chosen in some random manner. Certainly, the earmarking of the treatment funds for just those people in a particular part of the country would be open to a charge of unfairness. Why then, should it be any more fair to earmark public health-care funds for expenditures that will benefit only those people living in the future?

The question is not an easy one to answer. There may not, in fact, be any entirely satisfactory answer. The situation *may* be one in which a choice simply has to be made between what would be completely fair and what would minimize suffering. However, some attempt can at least be made to defend the research-centered allocation scheme from the charge of gross injustice. It can, in particular, be suggested that the allocation of funds for research does in fact effect a sufficiently random distribution of benefits to be at least reasonably fair.

In the interest of clarifying this possibility, suppose for a moment that a king decides to distribute his remaining bottles of fine cognac among his people. There are, unfortunately, many more people in the kingdom than there are bottles in the cellar; and so, desirous of being fair about the business, the king has the lucky recipients chosen by lot. This procedure would in all probability pass muster from the point of view of the commonly recognized nonteleological principle of fairness. But what if the king decided to give *future* citizens a chance at the cognac as well? What if he had his minister decide by lot how many of the bottles should be given away now (by lot) and how many should be given away by lot in a hundred years. Would this be less fair? Perhaps one could not claim it to be any *more* fair, even though it would give a chance to more people. But one would, I think, be hard pressed to find it partial. (Notice that the question of whether a greater total of happiness might not result from the receipt by some people of bottles of a very great age is not really relevant to the question of the *fairness* of the scheme.)

In a similar manner, the research-centered approach to the allocation of public health-care funds can be said to be reasonably impartial in its distribution of benefits (freedom from discomfort). It is not a special preselected group of individuals that receive the benefits from the funds invested in research into a particular health problem. It is whoever happens to be around when that research finally effects the transition from Stage Two to Stage Three of the problem's history. And this may or may not include some of the people who are in existence when the funds are allocated—just as the recipients of the cognac under the doubly randomized distribution system might or might not include some who were alive when the scheme was established. To be sure, to the extent that the research-oriented approach can reasonably be expected to provide benefits preferentially to those living in the future, it can be said to be unfair. And indeed, it may always be the case that those living long after the allocation of certain funds for research will stand a better chance of benefitting from them than those who are very near the end of their lives at the time of the allocation. To this extent, the research-centered approach may always involve a residual amount of unfairness. It is, however, likely to be small. It would seem to be a part of the nature of research that its results are not predictable in any definite manner. Past experience may indicate that research pays off—without indicating just how soon any particular program of research is likely to do so. Thus at the time when certain public health-care funds are allocated for research (rather than for treatment or prevention), it will be impossible to say precisely how soon benefits will be derived by anyone. And because of this, the approach can be said to distribute benefits in a reasonably random way.

It thus appears that when a health problem displays a Stage-Two total-suffering curve that shows no sign of dropping, the allocaters of public health-care funds in today's societies—whether they are utilitarians or are simply interested in keeping overall suffering to a minimum—would be well advised to favor research over prevention and treatment. Such an approach would at least not be terribly immoral with respect to the commonly recognized rule of impartiality, and it would definitely offer the brightest prospect for the early advent of Stage Three.

NOTE

[1] (Belmont, California: Wadsworth, 1979). Rescher's article originally appeared in *Ethics,* 79 (April, 1969), 173-86. Also of interest is Leon R. Kass, "The New Biology: What Price Relieving Man's Estate?" *Science,* 174 (November 19, 1971), 779-88. The question of the relative importance of different health-care subfields *is* taken up by Alan Davis and Gordon Horobin in "The Problem of Priorities," *Journal of Medical Ethics,* 3 (September, 1977), 107-9. They argue that prevention should receive higher priority than treatment, with primary responsibility being placed on the individual.

A RECENT DIALECT SURVEY OF SOME TRAITS OF WISCONSINESE

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Students enrolled in Linguistics 101: *Human Language,* were sent out to interview speakers of English about a number of syntactic and lexical items. This paper represents the first tabulated data from such a series of interviews, collected over Thanksgiving vacation 1978.

The students were asked to interview one speaker from each of the following age groups; 15-25, 40-50, and 65 and older. This type of sample is extremely useful for showing language change, as well as being convenient for gatherers since they could interview a friend or sibling, a parent, and a grandparent. Of the 360 questionnaires returned, 204 were tabulated. These speakers were chosen because they had grown up in Wisconsin, both parents were from the Great Lakes or Upper Midwest States and their grandparents came either from these same states or a non-English speaking country. All the speakers were Caucasian. Speakers from the Chicago and Minneapolis areas were also tabulated for the sake of comparison. No attempt was made to differentiate socio-economic classes.

The first construction to be examined is the use of 'once' to mean 'right now' or 'right away'. The sentence presented to the speaker was, "Come here once, I gotta tell you something." 67% of the young group admitted using this construction, 45% of the middle-aged group, and 25% of the older group. When asked if they had heard the construction before, nearly 100% stated they had. Of the speakers in Chicago 20% used the construction. Of those in the Minneapolis area only 6% used sentences of this type. The majority of speakers in Chicago and in Minneapolis denied having heard this type of sentence before. So, we can see that this construction is spreading in Wisconsin. If we look at the statistics for the Milwaukee area, we find a higher percentage of speakers using sentences of this type: 56% of the young group, 83% of the middle-aged group and 33% of the older group. This is significant because people in the middle group are probably more conscious of styles of speech than the other two groups. The young group has not yet found a need to develop styles, since their life experiences have mostly been within the family and a closed circle of friends. The older group has cast off a variety of styles since they are no longer as interested in job advancement as they once were. The people in this middle category have a great deal of influence over the speech of the population as a whole via television, schooling, advertising, etc. Perhaps the reason we see such a high percentage of Wisconsin youth using this construction is that it is spreading from Milwaukee, as a focal area, to the developing speech of the young in the state as a whole.

The second construction to be examined is the use of 'already' to mean 'right away' as in the following sentence said of getting into a car, "Get in already." 43% of the young group admitted using this construction, 33% of the middle group and only 15% of the older group. Here again Milwaukee county had higher percentages; 70%, 67%, and 67%. Chicago had 100%, 56% and 0%; Minneapolis had 0%, 33% and 50%. So, both here in Wisconsin and in the Chicago area the construction seems to be spreading, while in Minneapolis it is dying out.

The third construction under discussion is the use of 'yet' to mean 'still'. The sentence used in the study was, "Is there turkey yet?" asked by someone arriving late to a Thanksgiving dinner who wants to know if some turkey remains to be eaten. The percentages for this construction remain relatively constant throughout the different groups: 31%, 29% and 25%. In Chicago only one speaker in fifteen used the construction and in Minneapolis only one in sixteen. This type of sentence is primarily used in rural counties across the central part of the state: Fond du Lac, La Crosse, Manitowoc, Sheboygan, Washara, and Winnebago.

Construction four dealt with sentences of the type, "Do you wanna come with?". This construction comes from the German verb 'mitkommen' 'to come with'. This construction can be found in all parts of the United States where German immigrants comprize a large percentage of the inhabitants and where the German heritage is strongly felt. In Wisconsin the percentages were 77%, 60% and 35%. In Chicago, where this construction is known to be wide-spread, the percentages were 100%, 75% and 100%. Minneapolis also had high percentages, 100%, 50%, and 100%. But the interesting fact about this construction is that 91% of the young women in Wisconsin used this construction as compared to 44% of the young men. This finding supports the sociolinguist William Labov's assertion that women are in the forefront of linguistic change. As the primary teacher of children both as mother and elementary instructor, women instigate and carry on linguistic change.[1]

The last construction looked at was the use of the phrase "come by me" to mean "visit." The example used was spoken by one friend to another over the telephone, "Come by me on your way home from work today." This usage comes from the construction in German, "Kommen Sie vorbei." The percentage of users of this construction was very small in Wisconsin and the construction seems to be dying out: 8%, 8%, and 22%. No speakers in Chicago or Minneapolis used this construction. The construction was recorded primarily in Fond du Lac, Ozaukee, Sheboygan, and Wood counties.

The most interesting lexical item studied was the word used for an apparatus which dispenses drinking water. We wanted primarily to study the percentage of speakers who used the word 'bubbler' compared to the words 'fountain', 'water fountain', and 'drinking fountain'. We found a significant difference in the percentage depending on whether the apparatus was indoors or outdoors. For indoors the percentages of speakers who said "bubbler" were 58%, 32%, and 33%. These increased to 76%, 59%, and 37% when the bubbler was outdoors. The percentage of speakers in Minneapolis and Chicago who used the word 'bubbler' was insignificant. A very interesting fact the indoor/outdoor distinction showed was that 34 people switched from some form of the word 'fountain' to 'bubbler' when going from indoors to outdoors, whereas only ten switched from 'bubbler' to some form of the word 'fountain'.

I have spent some time trying to track down the etymology of the word 'bubbler'. Ms. Marilyn Boeldt of the Kohler Company in Kohler, Wisconsin has assisted me by providing information from *Kohler of Kohler News,* the company newspaper of the Kohler Company. The first time the term 'bubbler' appeared was in 1914 when it occurred alongside, and meaning the same thing as, the technical term 'bubbling valve'. It seems as though the terms were in free variation, in other words, used interchangeably in Kohler's 1914 catalogue. By 1919, the word 'bubbler' seems to have gotten the upper hand as the primary word, replacing 'bubbling valve'. Since the type of porcelain fountain with the bubbler on it became popular for outdoor use, and the water cooler and other types of dispensers were still used indoors, it seems only logical that a significantly higher percentage of speakers would use 'bubbler' for the outdoor fountain.

We also looked at the various words for parents, considered as a collective unit. 13% used the word 'folks'. 1% used the word 'rents', presumedly a shortening of 'parents'. The rest of the responses were for the standard word 'parents'. 'Folks' is found primarily in rural areas.

We hope that by continuing this project we will be able to resolve some of the mysteries of Wisconsin dialect and arrive at a clearer picture of speech in our state.

NOTE

[1] Labov, William, *Sociolinguistic Patterns*, University of Pennsylvania Press, 1972, pp. 301-302.

THE CREATIVE ARTIST AS TRAVELER: ROBERT LOUIS STEVENSON IN AMERICA

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On August 7, 1879, the *S. S. Devonia* steamed down the Clyde carrying Robert Louis Stevenson second class to New York. *The Amateur Emigrant* is his record of his experience on the *Devonia* and on an immigrant train to California. Portions of *The Amateur Emigrant* deleted in earlier editions have been replaced in the collection *From Scotland to Silverado* edited by James D. Hart.[1] In his introduction, Hart points out the greater maturity of *The Amateur Emigrant* compared to Stevenson's earlier *Travels with a Donkey* and *An Inland Voyage* (pp. xxxvii-xxxix) and suggests that the deleted portions "deepen and extend the sense of Stevenson's second-class passage" (p. xl).

The sense of Stevenson's journey from Glasgow to Monterey is of an experience more meaningful, more universal, than simply an uncomfortable three weeks compounded of noisome smells. sickness, heat and vermin. The real journey that he records is a symbolic statement of progressive loss of identity. He is cut off and adrift in an uncharted void, traveling endlessly in a nightmare in which nothing is as it seems to be or as it should be until at last even the destination ceases to have significance. Throughout the work the images reinforce this alienation. Only on the last page, devoted to his eventual arrival at San Francisco, is there any feeling of fulfillment, any small sense of returning reality. Though he repeats the word "new," writing of "new creatures within and without" watching the sun rise on a "new day" in a "new country" (p. 146), the impression of the preceding hundred and forty-five pages is too strong to be dispelled.

The depth to which Stevenson was affected by his experience is evident in a letter written to Edmund Gosse about a month after his arrival.

> I fear this can hardly be called a letter. To say truth, I feel already a difficulty of approach; I do not know if I am the same man I was in Europe, perhaps I can hardly claim acquaintance with you. My head went round and looks another way now; for when I found myself over here in a new land, and all the past uprooted in the one tug, and I neither feeling glad nor sorry, I got my last lesson about mankind; I mean my latest lesson, for of course I do not know what surprises there are yet in store for me. But that I could have so felt astonished me beyond description. There is a wonderful callousness in human nature which enables us to live.[2]

It is the purpose of this paper to examine the images that contribute to Stevenson's symbolic statement, images that in their deeply ironic nature mark his increasing disorientation. Traditionally, the ocean voyage has been used as a symbolic projection into the unknown. To Stevenson the significance of his voyage must have been poignantly apparent. Already estranged from his family, he had been called to California because of the serious illness of Fanny Osbourne, his future wife. Unlike his companions on the voyage, though he has cut himself adrift from his past, his purpose in doing so has not been to find a new life of greater promise. In the title and throughout both parts of *The Amateur Emigrant* he consistently uses the word "emigrant." He never becomes an "immigrant." The usage implies an emphasis on the "going out" or cutting adrift rather than the "coming in" or arrival.

For Stevenson the ship is the last bond with the known, secure world of the land that he has left. As a small projection of the shore, it represents security in contrast to the unknown sea, the unknown future. Thus, it is described in terms of the known with images familiar to dwellers on the shore. The passengers belong for the space of the voyage "to one small iron country on the deep" (p. 10). They are a "little nationality" in an "iron world" (p. 17) in which at night they gather "at the aftermost limit of our domain, where it bordered on that of the saloon" (p. 15). So completely does Stevenson impress this image of ship as world that the substitution in the cliché, "And I would have gone to the ship's end and back again for an oyster or a chipped fruit" (p. 76) passes almost unnoticed.

On first seeing the *Devonia,* he describes it as "a wall of bulwark, a street of white deck houses, an aspiring forest of spars, larger than a church, and soon to be as populous as many an incorporated town in the land to which she was to bear us (p. 3). But beyond the known limits of this "parishful of people" (p. 26) stretches the sea and the unknown future. The end of the journey is an unidentified "land to which she was to bear us" rather than a destination specified by name.

David Daiches in his short study comments on Stevenson's use of the contrast between exterior and interior backgrounds, specifically in *Treasure Island.*[3] In *The Amateur Emigrant,* the small, enclosed areas of the ship are safe refuge from storms and danger as, according to Daiches, the parlor of the Admiral Benbow Inn would become later. Though much about the ship and particularly the steerage is offensive to Stevenson, even his cabin becomes a metaphorical "oasis" (p. 4).

Stevenson extends the sense of a small plot of humanity adrift in vast space with a parallel image. At night the steerage passengers gather in a sheltered area near the deckhouse to sing and link their arms to steady themselves against the movement of the ship. "It was a general embrace, both friendly and helpful, like what one imagines of old Christian Agapes. I turned many times to look behind me on the moving desert of seas, now cloud-canopied and lit with but a low nocturnal glimmer along the line of the horizon. It hemmed us in and cut us off in our swift-travelling oasis. . . . And small as was our iron world, it made yet a large and habitable place in the Atlantic, compared with our globe upon the seas of space" (p. 17).

The *Devonia* is adrift in time as well as space. Stevenson describes the futile attempt of one of the passengers to retain a sense of time. She was determined to keep her watch on Glasgow time—the only "time" she has ever known—until she reached New York.

> They had heard reports, her husband and she, of some unwarrantable disparity of hours between these two cities. . . . It was a good thing for the old lady; for she passed much leisure time in studying the watch. Once, when prostrated by sickness, she let it run down. It was inscribed on her harmless mind in letters of adamant that the hands of a watch must never be turned backwards; and so it behoved her to lie in wait for the exact moment ere she started it again. When she imagined this was about due, she sought out one of the young second-cabin Scotsmen, who was embarked on the same experiment as herself and had hitherto been less neglectful. She was in quest of two o'clock; and when she learned it was already seven on the shores of Clyde, she lifted up her voice and cried "Gravey!" (pp. 7-8)

Images of a world devoid of habitual reference points are even more marked in Part II of *The Amateur Emigrant.* Fleetingly in Pennsylvania the landscape reminds Stevenson of England but this is a world in which all markers have been reversed and "the sun rises with a different splendour" in America. "It may be from habit, but to me the coming of day is less fresh and inspiriting in the latter; it has a duskier glory and more nearly resembles sunset; it seems to fit some subsequential, evening epoch of the world" (p. 104).

In this brief lightening of his spirits, Stevenson makes explicit the contrast between the images of known land and unknown sea. "For we are creatures of the shore; and it is only on shore that our senses are supplied with a variety of matter, or that the heart can find her proper business. . . . If I must indeed look upon the ocean, let it be from along the seaboard . . . dotted at sundown with the clear lights that pilot home bound vessels" (pp. 105-106).

Unlike the ship, the train is never an oasis. He cannot turn from the endless wastes to its interior security. Perhaps, as a consequence, his descriptions of the Nebraska plains are particularly vivid. "It was a world almost without a feature; an empty sky, an empty earth; front and back, the line of the railway stretched from horizon to horizon, like a cue across a billiard-board; on either hand, the green plain ran till it touched the skirts of heaven" (p. 123). Though he is projecting the experience of the early settlers, the feelings are his own when he writes, "Yet one could not but reflect upon the weariness of those who passed by there in old days . . . with no landmark but that unattainable evening sun for which they steered, and which daily fled them by an equal stride. They had nothing, it would seem, to overtake; nothing by which to reckon their advance; no sight for repose or for encouragement; but stage after stage, only the dead green waste underfoot, and the mocking, fugitive horizon" (p. 124). He longs for the mountains, imagining, perhaps, the familiar shapes of the Highlands, but "Alas! and it was a worse country than the other. . . . Hour after hour it was the same unhomely and unkindly world about our onward path" (p. 127).

In addition to a diminished sense of time and place, there is a consistent distortion throughout the journey of the familiar bases of social interaction and each contact is fraught with an overwhelming irony. For example, Stevenson paints a glowing picture complete with battle metaphors of the popular concentration of the emigrant. But, he says, "This is the closest picture, and is found, on trial, to consist mostly of embellishments. . . ." The truth is that, "We were a shipful of failures, the broken men of England" (pp. 10-12).

When Stevenson tries to find help for a sick man lying on the deck, the crew members are concerned only over the possibility that he may be another seaman and the steward says, "That's none of my business . . . I don't care" (p. 47-48). On the immigrant train, the conductor refuses to answer a question and turns his back on Stevenson. Later he is heard to explain, "It was . . . his principle not to tell people where they were to dine; for one answer led to many other questions, as what o'clock it was; or, how soon should we be there? and he could not afford to be eternally worried" (pp. 120-121).

This kind of irony pervades the description of every one of Stevenson's encounters in Part II. From New York to Council Bluffs he is not on the immigrant train and thus has the comfort of a dining car. He asks the waiter if it is the custom in America to tip. "Certainly no, he told me. Never. It would not do. They considered themselves too highly to accept. They would even resent the offer." And still protesting, he pockets the tip (p. 108).

He meets a widow with children on the train who allows him "to buy her children fruit and candies; to carry all her parcels, and even to sleep upon the floor" so that she could have his empty seat. When she leaves she says, "I am sure . . . we all *ought* to be very obliged to you" (pp. 109-110).

A railway official at Council Bluffs sells, for his own profit, pillows and boards to be placed between the seats for sleeping. The price is two dollars but has fallen to one and a half before the train leaves. At the first stop, people come aboard selling the pillows at fifteen to twenty-five cents with no charge for the board (pp. 116-118).

When the train stops at Elco, Nevada, three men approach Stevenson and one offers him work saying, "I'm running a theatre here, and we're a little short in the orchestra. You're a musician, I guess?" When Stevenson says he is not, "He seemed much put out of countenance; and one of his taller companions asked him, on the nail, for five dollars." Though his fellow passengers are encouraged at this indication of an abundance of jobs, Stevenson says, "I am not so sure that the offer was in good faith. Indeed, I am more than half persuaded it was but a feeler to decide the bet" (pp. 144-145).

The climactic instance of the discrepancy between the seeming and the real is Stevenson's description of the passing of immigrant trains. "As we continued to steam westward toward the land of gold, we were continually passing other emigrant trains upon the journey east; and these were as crowded as our own. . . . Whenever we met them, the passengers ran on the platform and cried to us through the windows, in a kind of wailing chorus, to 'Come back.' On the plains of Nebraska, in the mountains of Wyoming, it was still the same cry, and dismal to my heart, 'Come back!' " (p. 137).

In a world in which all familiar signs and markers are missing, Stevenson loses his identity. He has witnessed the same loss in the steerage passengers. Stripped of individuality and dignity they are, as Hart mentions in his introduction (p. xl), "human animals" herded into "stalls" and "pens." Animal images are used throughout in descriptions of the immigrants. Waiting to board the boat for Jersey City they "stood like sheep, and . . . the porters charged among us like maddened sheep-dogs" (p. 101). On the train, "We pigged and stewed in one infamy" (p. 138), and as the cars approached, "there would come a whiff of pure menagerie" (p. 133).

Stevenson shares the loss of individuality with the immigrants. At Council Bluffs, he stands "in front of the Emigrant House with more than a hundred others, to be sorted and boxed for the journey" (p. 115). The process has begun on the ship on the superficial level of class distinction. He realizes that by traveling second class he is seen as lower class, treated by the steerage passengers as one of themselves and looked down upon by the first class travelers. "For here I was among my own countrymen, somewhat roughly clad, to be sure, but with every advantage of speech and manner; and I am bound to confess that I passed for nearly anything you please except an educated gentleman. The sailors called me 'mate,' the officers addressed me as 'my man,' my comrades accepted me without hesitation for a person of their own character and experience, but with some curious information" (p. 72).

With a touch of humor he introduces an image to which he returns throughout Part I.

> In the steerage there are males and females; in the second cabin ladies and gentlemen. For some time after I came aboard I thought I was only a male; but in the course of a voyage of discovery between decks, I came on a brass plate, and learned that I was still a gentleman. Nobody knew it, of course. I was lost in the crowd of males and females, and rigorously confined to the same quarter of the deck. . . . Still, I was like one with a patent of nobility in a drawer at home; and when I felt out of spirits I could go down and refresh myself with a look of that brass plate. (pp. 5-6)

Later he says, "I was taken for a steerage passenger . . . and there was nothing but the brass plate between decks to remind me that I had once been a gentleman" (p. 72). When a woman from steerage is taken ill beneath the gaze of the first class passengers on the hurricane deck, they assume Stevenson is her husband and he ruefully confesses, "I was chagrined at this. Now was the time for me to go and study the brass plate" (p. 74).

Next, his profession is called in doubt. "To such of the officers as knew about me . . . I appeared in the light of a broad joke. The fact that I spent the better part of my day in writing had gone abroad over the ship and tickled them all prodigiously. Whenever they met me they referred to my absurd occupation with familiarity and breadth of humorous intention. Their manner was well calculated to remind me of my fallen fortunes. You may be sincerely amused by the amateur literary efforts of a gentleman, but you scarce publish the feeling to his face" (p. 74).

Eventually this entropic process reaches to a basic level of his personality. "The steerage conquered me; I conformed more and more to the type of the place, not only in manner but at heart, growing hostile to the officers and cabin passengers who looked down upon me, and day by day greedier for small delicacies. . . . The offer of a little jelly from a fellow-passenger more provident than myself caused a marked elevation in my spirits" (pp. 75-76). There is a complaint about the food and Stevenson is asked to look over the bill of fare and each day as he leaves the steward fills his pockets with greengages. "I have not been in such a situation since I was a child and prowled upon the frontiers of a dinner party . . . and if I was still a gentleman on a brass plate, in relation to those greengages I may call myself a savage" (p. 77).

Stevenson is perfectly aware of the symbolic structure he is fashioning. He says, "Travel is of two kinds; and this voyage of mine across the ocean combined both. 'Out of my country and myself I go,' sings the old poet: and I was not only travelling out of my country in latitude and longitude, but out of myself in diet, associates and consideration" (p. 72).

Rain falls the whole time Stevenson is in New York. His clothes are soaked and he leaves them behind "for the benefit of New York city." He has mentioned clothes as reflections of identity several times and here he says, "With a heavy heart I said farewell to them as they lay a pulp in the middle of a pool upon the floor of Mitchell's kitchen. I wonder if they are dry by now" (p. 99).

Perhaps the most poignant statement Stevenson makes on his experience is his conclusion to a rather mundane event on the train. He says of a drunkard who has been thrown from the train, "He carried a red bundle . . . and he shook this menacingly in the air with one hand, while the other stole behind him to the region of his kidneys. It was the first indication that I had come among revolvers, and I observed it with some emotion" (p. 112). The drunkard, intimidated by the conductor, staggers off down the track followed by the laughter of the passengers. Unobtrusively, Stevenson makes the central statement of his odyssey in the next sentence. "They were speaking English all about me, but I knew I was in a foreign land" (p. 113).

Images of sickness and death, the final loss of identity, complete Stevenson's portrayal of the process of disorientation. In his hotel in New York, he can hear the men in the next room, and "the sound of their voices as they talked was low and moaning, like that of people watching by the sick." His companion "tumbled and murmured, and every now and then opened unconscious eyes upon me where I lay. I found myself growing eerier and eerier . . . and hurried to dress and get downstairs" (p. 96). Later, on the train, he says, "the shadows were confounded together in the long hollow box of the car. The sleepers lay in uneasy attitudes . . . flat upon their backs like dead folk" (p. 128).

Stevenson has, indeed, come a long way out of his country and himself. As he shapes the scenes and events of the physical journey from the Clyde to Monterey, they become increasingly significant of his interior journey—a journey of the spirit which left him, as he wrote to Gosse, with his head turned around and looking the other way.

NOTES

[1] Cambridge, Mass., 1966. All quotations from *The Amateur Emigrant* are from this edition.

[2] Sidney Colvin, ed. *The Letters of Robert Louis Stevenson* (New York, 1911), I, 289.

[3] *Robert Louis Stevenson* (Norfolk, Conn., 1947), p. 38.

RICHARDSON'S ARISTOCRATS: A STUDY IN THE LIMITS OF FREEDOM

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Samuel Richardson's fascination with freedom and his fascination with the figure of the aristocrat are closely related. As Richardson conceives him, the aristocratic man is, at least potentially, the freest of all human creatures.[1] Free from the pressures which generally circumscribe conduct—discipline in childhood, financial necessity, and the social and legal sanctions which punish anti-social behavior—the aristocrat can define his selfhood and choose his own destiny in a way that enthralled Richardson's imagination. His social position not only liberates the English aristocrat from control by others, but also offers him an opportunity to govern the lives, and even the physical reality, around him. To a great degree, he can create his own world and his liberty at times seems to be that of a God.

All Richardson's major characters demand freedom and fight for it with desperate tenacity. But characters like Pamela and Clarissa ask only the irreducible minimum of freedom: the liberty to obey God's laws as they themselves interpret them. They may desire, but they would never demand, control of their time, their employments, the fates of those around them—or even of their own fates where moral imperatives are not involved. That Pamela and Clarissa expect so little liberty—and that their world attempts to deny them even that little—is a function partly of sex and partly, in Pamela's case, of class. At one extreme of Richardson's world, then, are powerless women, struggling for the basic freedom of moral choice without which they will be less than fully human and, at the other, are aristocratic men like Mr. B and Lovelace, demanding the right to impose all their impulsive desires upon the reality around them.

The education of the gentleman was a popular topic in conduct books of the seventeenth and eighteenth centuries. An unpublished work of Defoe's, *The Compleat English Gentleman,* discusses the absence of discipline characterizing the usual gentleman's upbringing in a way that is close to the view of the subject which Richardson's novels express. The indulgent mother of a son born to inherit a great estate will be unwilling, Defoe asserts, to subject him to the discipline of his social inferiors in a public school. Such a mother will yield to her natural fondness and to her pride in her son's social superiority and will engage a tutor willing to be no more than a toady to her heir. The son himself will early understand his importance as the future representative of a great family and the power that his position gives him over his parents. Thus he will be deprived of the discipline which most children receive at school *and* at home.[2] Similar criticisms of aristocratic education appear in other conduct books of the period, such as Richard Allestree's *The Gentleman's Calling* (1679) and Clement Allis's *The Gentile Sinner* (1660). Both Richardson's libertine villain/heroes, Mr. B and Lovelace, fit the pattern traced by Defoe and other conduct book writers: they have been raised primarily by mothers who could not bear to see them contradicted or corrected. And each boy is the only male representative of an ancient family and the heir to a great estate.

In adulthood, Richardson's aristocrats prove to be even freer from coercive pressures than they were as children. Provided they are minimally careful not to injure their estates, they need not worry about money. Their peers in the aristocracy and gentry will accept them on the basis of their social position and will regard a hefty amount of misconduct as appropriate to, or at the very least tolerable in, someone of their status. The idea that the aristocrat is born for pleasure, not duty, was an all too common one, both Richardson and many writers of conduct books felt. This point could hardly be made more emphatically than in the scenes in *Pamela* where Mr. Williams tries to get one of the neighboring gentry to intervene on behalf of the imprisoned girl and encounters in succession apathy, mild sympathy overruled by an unwillingness to antagonize so powerful a man as Mr. B, and finally, on the part of Sir Simon Darnford, the feeling that B's treatment of his servant is quite acceptable since he is merely exercising a modified *droit du seigneur.* " 'He hurts no family by this' " Sir Simon comments (p. 138), while the parish minister remarks tolerantly that " 'Tis what all young gentlemen will do' " (p. 139).[3]

If neither the conscience implanted by a strict upbringing, financial necessity, nor social pressure, provide effective checks on the aristocrat's freedom of action, that leaves only the coercive power of the law as a possible limiting force. But Richardson makes it clear that the determined aristocrat has little reason to fear legal punishment for even the most heinous behavior. The aristocrat's role as local Justice of the Peace, ideally a duty he owes to society, if abused becomes a means of escaping punishment, or even of furthering his own wickedness. Mr. B issues a warrant for Pamela's arrest, which he intends to use should she manage to escape him. Indeed, the many mock trial scenes in the two parts of *Pamela* poignantly emphasize the abuse of authority of which B is guilty. Pamela, the innocent party, must play the culprit, while the guilty B, with all the power of society to back him, usurps the roles of accuser and judge. Lovelace reflects cynically on his chances of escaping punishment for the rape of Clarissa and concludes, quite accurately, that between Clarissa's natural disinclination to air the matter in court, the sympathy his connections and good looks would procure from any jury, and the readiness of juries to believe that a rape victim must have encouraged her assailant, he is quite secure. Lovelace considers a variety of audacious crimes, including murder, in the course of *Clarissa,* and if in end he decides not to commit most of them, it is not fear of the law that stops him.

The theory upon which England's constitution is based, that an aristocrat's stake in the country is a sufficient guarantee for his good behavior, since it would be irrational for him to do anything either to injure the nation or imperil his own share in it, is one which Richardson finds laughably simplistic. It is cited several times by Lovelace's acquaintances as a reason why Lovelace surely will not commit this or that enormity (eg. Vol. IV, p. 144, p. 253).[4] Such reasoners, Lovelace notes, are definitely wrong to assume that he must always "prefer his interest to his pleasure" (Vol. IV, p. 248). In fact, his stake in the country actually makes Lovelace more willing to defy the law than a poorer man would be—for he can always flee to the continent and live there comfortably on what he can salvage of his fortune. "All countries of the world are alike to me," he claims (Vol. II, p. 39). The code of honour, which might be regarded as a survival of an earlier age's system of enforcing justice, though it threatens sanctions for bad behavior, is not much feared by aristocrats who, like B, choose their victims from the lower classes, or who, like Lovelace, are masters of all offensive weapons.

Freedom from fear, from want, from the coercion of other men, in both childhood and maturity—what sort of personality will such a situation produce? Richardson's paradoxical answer is that too much freedom creates a personality which will enslave itself far more effectively than it could be enslaved by any outside force. The process can be seen in a mild form in Mr. B, far more dramatically in Lovelace—of Richardson's major aristocratic characters only Sir Charles Grandison escapes unscathed.

Pride—the need to respect oneself and to be respected by others—is one of the strongest human drives in the world of Richardson's novels. But the need for respect can assume a multitude of shapes and align itself with a dazzling variety of ideas and emotions. Pamela, having no social status to be proud of, glories in her honesty and repeatedly reminds Mr. B that, though not his social equal, she is his superior in the eye of God. It is pleasantly ironic that after she becomes Mr. B's wife, the nature of Pamela's pride changes and she remarks that her only source of self-congratulation is that "I have been raised to a condition where I have power to do good"—for "what am I in myself to be proud of?" (p. 528). The alliance between Pamela's strict moral standards and her need for self-respect is clearly demonstrated by this shift. The prostitutes in *Clarissa* are also motivated by pride in their almost frantic desire to see "the divine Clarissa" brought down to their own level. Her degradation will prove "the sex's" universal frailty and will thus excuse their own weaknesses.

The eldest son of an ancient family, raised in an environment where everyone around him is his inferior and his slave, develops a distinctive type of pride. He has never been forced to live up to a demanding moral code and hence cannot pride himself on his successes as a moral agent. Totally undisciplined, he has never developed a conscience and so cannot derive self-respect—as Pamela and Clarissa do—from his consistency in obeying its orders. But he *has* received constant deference and submission from those around him, and it is natural that his pride will be gratified only so long as he continues to receive such tokens; tokens which, as he well knows, are tributes paid to his social position, rather than to his individual merit. So the aristocrat will be proud not of what he is, but of the way other people treat him.

Lovelace displays the most radical disjunction imaginable between his own consciousness of inner moral value and the outward deference he exacts. Lovelace's pride is always of the bottom line variety: if he can gain deference and submission in the end, he does not care how much he need lie, cheat, or abase himself along the way, as his treatment of Clarissa demonstrates. In his attempts to make her his pliant and deferential mistress, Lovelace is not merely guilty of the most varied and despicable misconduct, but further, Clarissa continually catches him misbehaving and responds with heartfelt contempt. But Lovelace perseveres, for he believes that his final triumph over Clarissa will cancel all intervening humiliations, though he is keenly aware of the ridiculous, degraded figure he often cuts in her eyes. Deference is more important to Lovelace than any of life's more solid pleasures. He feels no desire to seduce Rosebud once his power over her has been acknowledged.

Lovelace's pride feeds on the degradation of others and in the process degrades Lovelace himself—yet this destructive pride is a direct result of Lovelace's extreme, but characteristic, aristocratic childhood. And the characteristic freedom of the aristocrat has molded Lovelace's personality in ways that are even more dramatic. Because Lovelace has never been forced to obey any rule except that of his own desires, he finds the idea that his freedom should be circumscribed in any way both humiliating and intolerable. Lovelace does not merely refuse to obey the laws of morality or the laws of England, he refuses to be bound by any rules of thought or language which might impede him in his endeavor to make the world around him conform to his desires.[5]

Perhaps the most striking of the freedoms which Lovelace demands is his tacit refusal to be bound by the "laws" of empirical evidence. Lovelace likes to describe himself as an empiricist who bases his generalizations on his own wide experience and on a series of "experiments" which he has carefully performed. But as *Clarissa* progresses it becomes clear that Lovelace is simply a special pleader trying to prove the premise that Clarissa's morals can be corrupted and not, as he likes to think, an unbiased experimenter testing the limits of virtue as a participant/observer. Lovelace's pride is largely responsible for his tenacious commitment to the idea that all virtue is a sham and that every woman has her price. For if all virtue is a sham, Lovelace, like the prostitutes who share his desire to degrade Clarissa, need feel no shame about his own lack of virtue. Thus Lovelace goes on "trying" Clarissa even after he has collected an overwhelming amount of evidence that her resistance is as sincere as it is violent and that her health is crumbling under the strain of her fear. Quite early in the novel, when Lovelace is still using adjectives like "blooming" and "glowing" to describe Clarissa, Belford is shocked by her weak and haggard appearance. (Vol. IV, p. 94) Clearly Lovelace must ignore the physical damage to Clarissa if he is to continue his attempt to make the bottom line of their relationship come out as he wishes. What he pretends is an empirical generalization about the universal corruptibility of women, is really an ideological position to which he is so deeply committed that he will ignore any amount of evidence suggesting its falsehood, in his desperate attempt to *make* it true. Lovelace's interpretations of the events he observes become ever more bizarre and strained as the novel progresses and perhaps his attitude toward evidence is most clearly shown by his request that Belford pretend to him that the dying Clarissa is recovering: "I will go abroad rejoicing and believing it and my wishes and imaginations shall make out the rest." (Vol. VIII, p. 321) Thus, by the end of the novel, Lovelace acknowledges that he is not an empiricist, but an artist determined to make the visions of his imagination a reality.

Lovelace does not allow his thought processes to be restricted by the rules of logical, consistent reasoning any more than he allows them to be trammeled by the demands of empirical evidence. "Regardless shall I be in all I write of connection, accuracy, or of anything but my own imperial will and pleasure," he tells Belford (Vol. III, p. 63). Up to a point this is playfulness on Lovelaces 'part, but beyond that point he becomes quite serious in his refusal to accept an unpalatable conclusion merely because it follows logically from valid premises. In such a situation, Lovelace is always prepared to take elaborate evasive action. His letters are filled with the most maddeningly perverse arguments, always bolstering the conclusion to which he is emotionally committed. Concerning the basic question of whether he *must* continue his attempts on Clarissa, Lovelace sometimes argues that because Clarissa does not love him, it is necessary that he punish her by seducing her. But at other times her attitude seems more favorable and at those times Lovelace tells himself that if Clarissa does love him, then he must seduce her because he has a good chance of getting away with it. Lovelace never admits these two arguments cannot, simultaneously, be true—nor does he admit that each argument undercuts the other. If Clarissa loves him there is no reason for punishment, and if she doesn't, his seductive wiles are unlikely to succeed. He continues to use the two arguments in all their logical incompatibility as supports to the conclusion at which he has already arrived.

Lovelace often defines a category most perversely in order to bolster his decision that a particular individual must be treated as Lovelace wishes to treat him, because he is a member of that category. When he wants to strengthen his resolutions against Clarissa —and that is most of the time—Lovelace likes to remind himself that a "triumph" over her will be a "triumph over the sex," which once wounded him in the person of the "quality jilt" who played him false, and secondarily a triumph over his enemies the Harlowes. (Vol. III, p. 83) It is true that Clarissa *is* a woman and a Harlowe, but by defining her in terms of those crude categories, Lovelace ignores both her extraordinary qualities as an individual and the unpalatable fact that mistreating her will, as Belford repeatedly points out, serve, rather than frustrate, James Harlowe's purposes. The categories Lovelace chooses are not those which best describe Clarissa or her situation, but they are the ones which most effectually bolster his resentful attitude and this is what he is after.

Lovelace's attitude toward language is nearly as libertarian as his attitudes toward evidence and logical reasoning. Lovelace seems to find restrictive and humiliating the idea that he ought to be satisfied to follow the linguistic conventions within which most people confine their communications. Thus he invents the Roman style for writing to his fellow rakes—and stipulates that they cannot take offense at anything written in that style. The Roman style thus permits Lovelace to use words freely without being affected by the usual consequences of such a practice. Nor does Lovelace care to be bound by the vocabulary of standard English. His neologisms are numerous; clearly he thinks that he can create a language fit to express his thought. Lovelace's constant, dazzling use of figurative language strains against the rules of both logic and language. Through the force of his bizarre metaphors, his refusal to confine himself to the literal meanings of words, Lovelace hopes to prove that reality is what it appears to him to be. His frequent descriptions of Clarissa as a bird seem intended to demonstrate—to himself and Belford—not merely that she is basically animal, though she seems to soar angelically, but also that what he is doing to her is not important. These metaphors are an attempt to escape the conclusions which would have to follow logically if he described her in standard English, as a woman possessing an immortal soul.

The freedoms which Lovelace demands for himself are complex, varied, and radical, and include a refusal to be bound by the commonly held "laws" of identity. We have seen that Richardson's aristocrats are generally treated with a consistent respect that is unaffected by the nature of their behavior. Perhaps as a result of this, Lovelace has come to believe that he possesses a self, to which other people respond, that is somehow completely separable from the personality he manifests in his actions. When his feigned illness succeeds in upsetting Clarissa, Lovelace is convinced that her love for him has not been affected by his past misbehavior and that he therefore has "credit for a new score" of misconduct. (Vol. V, p. 1) He thinks, in other words, that there is an inner, essential Lovelace whom Clarissa adores—and that her image of that Lovelace cannot be destroyed by anything the outer Lovelace may do. This idea is consistent with the exemption from consequences which Lovelace has always experienced, but it is not true of Clarissa's feelings for him. As Lovelace's behavior cumulatively and unmistakeably demonstrates his violence and sadism, Clarissa realizes that the man who attracted her is not the "real" Lovelace and her feelings readjust themselves accordingly. To the moment of her death, Lovelace cannot believe that this process has actually occurred, that it is irrevocable, and that the "self" he has in Clarissa's eyes is now based on the evidence of his actions. Lovelace's delight in disguises suggests his plastic approach to the idea of personal identity: he can temporarily become whomever it suits his purposes to be, without compromising that inner, essential Lovelace.

Lovelace believes that he has the power to influence, indeed create, both the world Clarissa perceives and the world that actually surrounds her. Lovelace has tricked Clarissa into taking up residence in Mrs. Sinclair's brothel, he has arranged to have accomplices impersonate various emissaries from Clarissa's family, he has invented elaborate circumstantial tales concerning a house which must be ready for occupancy before he and Clarissa can marry—yet he feels sure that he can keep the evidence of all these deceptions secret as long as he wants, that the reality he has created for Clarissa and the world he wants her to perceive can be kept separate and that he can control both. But Lovelace overestimates the plasticity of empirical fact even in the hands of a master deceiver. Clarissa gradually, by bits and pieces, picks up the evidence Lovelace's schemes would deny her and when she realizes that she is imprisoned in a brothel, she can successfully apply her superior wit to the problem of escape.

And this is what happens with all the excessive freedoms which Lovelace claims: moral truths and empirical facts reassert their primacy in the teeth of his most determined efforts to prove that he has the power and will to set them aside. The aristocratic claim of total liberty overreaches itself and produces total enslavement, a situation in which no effective courses of action are open. Lovelace's greatest problem stems from the fact that what he thinks of as empirically based generalizations which he is testing—"once subdued, always subdued," and the like—but which are really cynical axioms to which his pride is deeply committed, are simply not true in the theistic world of *Clarissa.* Lovelace is trying to create a debased, animalistic reality which sets God's law aside and Richardson believes that God will not let this happen: the divine spark of real virtue that never deserts Clarissa results from the mission and teachings of Christ and is stronger than Lovelace's best efforts to eradicate it. As Belford points out repeatedly, toward the close of the novel, the hand of Providence can be clearly seen punishing all those who have played roles in Clarissa's downfall. If a man is trying to remake God's world in his own evil image, to prove the truth of falsehoods, he will naturally fail, as Lovelace does. The evidence of his misconduct will accumulate in spite of his attempts to conceal it, the good in men will assert itself no matter how hard he tries to make universal corruption the order of the day.

Nor is Lovelace's boasted freedom circumscribed only by God's laws; he also finds that his own past actions acquire a momentum which, to his surprise, severely limits his present freedom of action. For example, in his war against the idea of virtue, Lovelace seduced and degraded Sally Martin and Polly Horton, who subsequently became prostitutes and partners in Mrs. Sinclair's brothel. During the period when Clarissa is residing at Mrs. Sinclair's, Lovelace is often inclined to acknowledge the hopelessness of his designs on her, to do her justice, and marry her. But Sally and Polly never permit Lovelace to retreat from his worst purposes —their pride, as we have seen, is involved in seeing Clarissa reduced to their own level. They ridicule Lovelace's best and most intelligent impulses as unmanly weakness and effectually prevent him from changing his mind in time. Yet Sally and Polly are what Lovelace has made them and the strong and evil influence they exercise is the direct result of his past actions.[6] Further, since Lovelace's pride is fed on the outward respect he receives from others, he is peculiarly susceptible to the influence of different companies: he is eager to earn the prostitutes' applause by displays of cynical machismo, but occasionally he is just as moved, in Clarissa's presence, by an impulse toward the virtue which will earn *her* approval. A man whose pride is of this externalized sort, will have less control over his actions than the man who cares only for the approval of his own conscience.

Lovelace's seduction attempts acquire a forward motion which also limits his freedom: each failed attempt is a humiliation to be redressed only by success on the next attempt, which therefore must be made. This means that the final attempt to subdue Clarissa, the rape, is virtually inevitable from the start. And the rape shows Lovelace to Clarissa in his true colors, thus destroying any possibility that she will become either his wife or his mistress. Lovelace's oft-repeated belief that he can have a wife at any time proves false, and he finds himself totally cut off from Clarissa, even before she makes her final escape in death. Lovelace suspects this, wondering if he has "put it . . . out of my own power to be honest. I hate compulsion in all forms; and cannot bear, even to be compelled to be the wretch my choice has made me . . . I am a machine at last and no free agent." (Vol. VI, p. 4) By claiming excessive freedom and letting his own lawless desires rule his behavior, Lovelace maneuvers himself into a position where all options are closed to him, where he lacks the power even to obey his own impulse to reform. In *Clarissa,* the truest freedom is the freedom the heroine finds at the end: to live by God's laws and to achieve a perfect union with God's goodness in death. The total freedom of the aristocrat is not merely an illusion, but an illusion which enslaves.

If Richardson is, in part, using Lovelace to demonstrate that the quintessential aristocratic upbringing censured by Defoe, Allestree, and other writers of conduct books does indeed produce a lawless and destructive personality, how does it happen that his remaining aristocratic protagonists, Mr. B and Sir Charles Grandison, are ultimately able to lead lives of happiness and social utility? In Mr. B's case it seems clear that his education differed somewhat from the conduct book paradigm and provided a foundation on which a reformation could later be based. Like the mothers in *The Compleat English Gentleman,* B's mother could not bear to see him (or, for that matter, his sister the future Lady Davers) thwarted. But where Lovelace's mother seems to have been motivated in her indulgence by her snobbish sense of her son's social superiority, B's mother, Pamela tells us, was a true Christian with a sense of duty to inferiors, who overindulged her children through mistaken impulses of kindness. The fact that she spoiled her daughter as thoroughly as she spoiled the male heir to the family name and possessions does indeed suggest that her motive was squeamishness, rather than pure snobbery. B was apparently influenced by his mother's sincere commitment to Christianity, even as he tried to reject it. Though the indulgence and deference which characterized his upbringing produced in B the typical sort of aristocratic pride, B feels, unlike Lovelace, that the Christian standard of moral judgement really does matter. He is uneasy when he knows himself to be morally wrong, and particularly so when others tell him of it. B's basic commitment to Christian moral standards, in conjunction with the love he feels for Pamela—a love which is far more sincere and less physical then he will admit to himself—makes him a peculiarly half-hearted and inefficient seducer and rapist.

A part of B wants, Lovelace-like, simply to dominate Pamela and to bring her down to his own moral level, but another part of B responds to Pamela's repeated charge that his immoral behavior has destroyed his dignity in her eyes, with a wish to earn Pamela's approval by deserving it. Under Pamela's tutelage, B finally comes to realize the truth which always evaded Lovelace: that obedience to God's laws earns one maximum respect from others, and from oneself, and eliminates the discrepancy between one's sense of inner deficiency and the outward respect necessary to one's pride, that plagues the rakish aristocrat. At the end of the novel, B is happy in Pamela's almost slavish deference, in the chorus of adulation his generous behavior and good taste gain him, and in the conviction that he is now on fine terms with God. The sense of superiority which Lovelace vainly sought by degrading others, B finds by elevating himself.

Nonetheless, the reader may find that there are difficulties raised by the almost effortless way B's problems are resolved and these difficulties are perhaps clues to the depth of Richardson's distrust of aristocrats. The first difficulty is B's mother. How could a truly Christian woman possibly allow her children to have their own way in everything, knowing what all Christians know about man's innate sinfulness and the need for control? Second, there is the problem raised by B's pride. Clearly, Richardson finds the idea of an aristocrat whose pride is not one of his strongest passions to be unthinkable and B and Sir Charles Grandison are every bit as proud as Lovelace himself. Therefore Richardson is afraid to trust the permanence of B's reformation to such a feeble reinforcement as the approbation of his own conscience. B needs Pamela's passionate adoration and the approbation of his social equals thrown into the scale if his pride is to fight on the side of his reformation. It is easy enough to see why B's reformation would earn Pamela's approval, but the chorus of admiration with which B's neighbors greet his behavior is hard to credit. The same snobbish attitudes which make it so hard for B to admit to himself that he is truly in love with a servant have been shown throughout the novel to be the predominant social values held by the gentry. If B's original reluctance to marry Pamela is as strong as we have been led to believe, then surely his neighbors, actuated by the same feelings, would not receive the match so warmly. B's pride is gratified and the novel's moral—that virtue is rewarded—is driven home by their warmth, but at the expense of consistency.

Some of the other ways B's marriage to Pamela gratifies his pride and his feeling that as an aristocrat he ought to be freer than other people, are more skillfully managed. Marriage to a social inferior assures B of a degree of submission, deference, and gratitude almost unthinkable in a woman of his own class. Further, it is rather charming to see B take advantage of his marriage to a servant to order the government of his family according to his own notions and to make it stricter and more moral than the families of his neighbors. Like Pamela earlier in the novel, B senses that he can redress any social disadvantages which his wife's lack of birth and wealth may have laid him under, by compensatory superiority in the moral sphere. B is convinced that he has gained not merely respect, but also aristocratic distinction and true freedom—the freedom to behave better than his neighbors; the only freedom to differ which does not offend God—from his decision to marry Pamela. But Richardson's reluctance to test B's reformation in the fire of unpleasant consequences suggests a conviction that the aristocrat, raised in pride and liberty, must be bribed to behave. Like those of the exemplary little girls in the nursery stories Pamela later tells her children, B's virtues bring social success too mechanically. Richardson can't convincingly imagine the upbringing which made B reclaimable and he can't quite trust B's reformation without stacking the cards in its favor.

In Sir Charles Grandison, Richardson presents his readers with an aristocrat who certainly has no need to reform. Even confirmed lovers of Richardson find Sir Charles a bit difficult to swallow—and the reason for this is not only the fact that Sir Charles is so perfect that he cannot grow or learn. Clarissa is nearly as exemplary as Sir Charles and if readers find her a much livelier and more convincing character, the explanation cannot simply be Sir Charles's marginally greater moral excellence. The problems with Sir Charles seem to arise from the complex and sometimes contradictory virtues he must embody, the sheer number of thematic functions he is expected to perform, for these varied functions create tensions within his character from which Clarissa's is relatively free. In order to embody completely Richardson's conception of the ideal gentleman, as it is his function to do, Sir Charles must at once be the proud aristocrat and the humble Christian, the man of action and the man of accurate self-awareness, the idol of women and the devotee of the virtue of chastity, the accomplished swordsman and the convinced pacifist, and so forth. No wonder his character seems to buckle beneath the weight of these contradictory virtues.

Sir Charles's character must be impossibly complex because he embodies the aristocratic ideal at a time of transition. As Margaret Doody puts it, "The rejection of the old ideal of the noble warrior hero in favor of the ideal of benevolent gentleman may be regarded as a part of a concerted effort of a whole society to make adjustment to a kind of communal life other than that of the small, self-contained unit, protected by the leader who can wield a sword."[7] Lovelace is a sword-wielding aristocrat of the old sort trying unsuccessfully to exercise domineering power in a peaceful modern society. B is an aristocrat who shifts, fairly painlessly, from the old to the new style. But in creating the character of Sir Charles, Richardson tried to guard his exemplary gentleman from criticism by proponents of either style of aristocrat—to give Sir Charles the military skill, the pride, passion, and style of the old warrior hero, but to make it quite clear that his commitment to the Christian ideals of benevolence and social duty is so strong that his "warrior" traits stand no chance of controlling his actions.

Like B and Lovelace, Sir Charles is clearly shown to be the product of his upbringing. Only son and favorite child of a selfish, careless, amoral father and a responsible, self-disciplined, Christian mother, Sir Charles received a moral education which was probably more effective than it would have been had both his parents been decent people. His mother provided not merely the discipline, but also the example, while his father's life was a tacit warning of what to avoid. Schooled in the art of self-defense by his father, Sir Charles also learned a truly Christian abhorrence of the code of honor from his mother. The respect in which his mother was held, her effectiveness in keeping the family running smoothly, proved to her son the value of the feminine virtues and prevented him from taking his father as a model, though his strong sense of filial duty forbade him to reject his father's masculine values completely. Sir Charles's youth was not free from the valuable lessons of affliction which, in Richardson's view, too many aristocrats escape altogether. Sir Charles lost his beloved mother when he was only sixteen and at that time was sent into prolonged exile on the continent, for his father did not want the heir at home to witness his own misbehavior.

As usual, Richardson has carefully provided his character with an education which accounts for his most prominent traits. Unlike Richardson's other aristocrats Sir Charles has always known discipline and frustration, so we have a legitimate reason for the fact that he prides himself more on the inner moral rectitude he has developed, than on the deference he receives. Nonetheless, the very elaborateness of the explanation offered for this phoenix of an aristocrat suggests that Richardson finds in him something very odd, in need of more than the usual amount of discussion. Such an education as his—an aristocratic mother so free from snobbery or laxity, an aristocratic father setting so unattractive an example, nature providing the afflictions which wealth can frequently spare a child—is an anomaly very different from the typical aristocrat's education discussed in the conduct books.

Carefully and elaborately as Richardson has accounted for Sir Charles's commitment to Christian values, he is almost as unwilling to try Sir Charles's virtue, as he was to try Mr. B's reformation, in the fire of unpleasant consequences. Although Sir Charles is occasionally treated cruelly and contemptuously by the old fashioned sort of arrogant aristocrat—like General Della Porretta—the self-controlled dignity with which he bears and reproves affronts always ends by winning him greater admiration and deference than he could have earned by any other method. And since this usually happens with almost magical speed, Sir Charles is never forced to choose between satisfying the demands of his conscience and gratifying his desire for respect, except for vanishingly brief periods. Richardson tells us repeatedly that Sir Charles is a proud man, but that his is a proper pride, which can only be gratified by consciousness of internal worth and which can stand against any amount of outward discouragement—the opposite of the pride produced by the typical aristocratic childhood. We also learn that Sir Charles is too proud to owe an obligation and that his pride receives its greatest satisfaction from his own consciousness of his great social utility: "My chief glory will be, to behave commendably in the private life," he tells Harriet when they discuss their plans for the future. He does not need public notice to bolster his sense of worth. Clearly Richardson's point is that there are many sorts of pride and that those who have been properly educated do not need deference in order to have self-respect. But after making this point, Richardson gives Sir Charles enough deference to satisfy even a Lovelace. It is probably not Sir Charles whom Richardson distrusts here, but rather his own readers, who, not possessing Sir Charles's firm moral standards, may need a great deal of encouragement to follow his example of good conduct.

Like all of Richardson's main characters, Sir Charles values his freedom highly. But for him, as a conscientious man, aristocracy means the freedom to behave better than his neighbors, to be more generous, to obey the laws of morality more consistently and strictly. And these things his wealth and liberal education enable him to do. This sort of freedom is social, for the man who values it is a benefit to all his fellows. And it is real freedom, because it is based on a realistic understanding of what a rich, good and determined man can, with God's aid, accomplish. Sir Charles is not an impulsive do-gooder, but an empirical scientist—of the sort Lovelace falsely claimed to be—who studies situations before he acts and who judges in terms of valid moral standards. Where Lovelace could only dream of possessing the freedom and power to reduce the reality around him to his own moral level, Sir Charles actually can raise the moral quality of the society around him through example, encouragement, and judicious aid. Where Lovelace boxes himself into a corner by claiming excessive, impious freedoms, Sir Charles, through his benevolence, continually extends the circle of his influence and power. More and more people fall under his spell, emulate his virtues, leave him their property, and thus his scope for changing the world around him is ever on the increase. Paradoxically, the aristocrat who voluntarily obeys the laws of God and man proves freer than the aristocrat who claims that, "The law was not made for such a man as me." (*Clarissa* Vol. IV, p. 109)

The egalitarianism of Richardson's novels disturbed many of his contemporaries. His claim that in a Christian world the soul of a servant like Pamela is every bit as important as the soul of her master, seemed radical and dangerous. *Sir Charles Grandison* is the most conservative of Richardson's novels, for its moral scheme is not the Christian egalitarianism of *Pamela* and *Clarissa,* but rather the notion of the Great Chain of Being, which is repeatedly discussed by the novel's characters. If one thinks of reality as a great chain, then all creatures are essential to God's plan, but some are clearly higher than others. And this is the moral idea that stands behind Grandison's social conservatism. Only those who are free from sordid compulsion, and who are well educated, can reach the greatest heights of moral discrimination and action of which humanity is capable. Such people need not be of the highest branches of the aristocracy—indeed we have seen that Richardson is deeply distrustful of an aristocratic education, and neither Sir Charles nor Harriet comes from a really great family, as Lovelace does—but they must at least be well-off and well-taught. Sir Charles and Harriet, with their incredible power to make the finest moral distinctions and their almost super-human ability to live up to their convictions, represent the top rung on a moral ladder. In *Grandison* Richardson develops an idea which was to become important in the work of later eighteenth and early nineteenth century novelists like Fanny Burney and Maria Edgeworth: that the aristocrat can, because of his greater opportunities to act and learn, become a better man than any member of the working or middle classes. But even in *Grandison,* his most conservative work, Richardson's suspicion of the aristocracy prevents him from arguing this proposition wholeheartedly and convincingly. Richardson's distrust of aristocrats impels him to hedge his ideal gentleman with a dizzying number of special conditions, explanations, qualifications—so many that they begin to undercut each other and to destroy the credibility of Sir Charles's character.

The importance of Richardson's work for the way aristocrats are treated in later novels cannot be overestimated. The two types of aristocratic characters which, in a multiude of varying forms, reappear in novels throughout the late eighteenth and nineteenth centuries first find novelistic expression in Richardson's work. The dark aristocrat, whose moral character has been destroyed by privilege, and the exemplary aristocrat, whose great opportunities have enabled him to reach a standard of excellence beyond the reach of ordinary mortals, have prototypes in other literary genres and in social theory, but as far as the novel goes, they are both Richardson's creations. Richardson liked the idea of an ideal gentleman but he was never really able to evade his conviction that the freedom of the essential aristocrat was a dangerous and destructive state of being. This conviction underlies the characterizations of B and Sir Charles and undermines the reader's belief in their virtues.

Notes

[1] In Britain the term "aristocrat" has never been completely clear in its application, for the British aristocracy is not a closed caste. I am using the term loosely here, to mean a man who has, or will inherit, a peerage, *or* who possesses, or will inherit, a great landed estate. B and Sir Charles fall into the latter category.

[2] Daniel Defoe, *The Compleat English Gentleman* (London, David Nutt, 1890).

[3] All references to Pamela incorporated in the text are taken from: Samuel Richardson, *Pamela or Virtue Rewarded* (New York, W. W. Norton and Company, 1958).

[4] All references to Clarissa incorporated in the text are taken from: Samuel Richardson, *Clarissa Harlowe: or The History of a Young Lady,* 9 vols. (Philadelphia, J. B. Lippincott Co., 1902).

[5] See John Carroll, "Lovelace as Tragic Hero," *University of Toronto Quarterly,* 42 (1973), pp. 21-24, for a similar, but abbreviated, discussion of the excessive freedoms Lovelace claims.

[6] For a more extended discussion of the evil influence that the women of the brothel have upon Lovelace, see: Judith Wilt, "He Could Go No Farther: A Modest Proposal about Lovelace and Clarissa," *PMLA,* 92 (1977), pp. 19-33.

[7] Margaret Doody, *A Natural Passion: A Study of the Novels of Samuel Richardson* (Oxford, The Clarendon Press, 1974) p. 242.

[8] Samuel Richardson, *Sir Charles Grandison* (London, Oxford University Press, 1972) Vol. III, p. 99.

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In the "Proteus" section of *Ulysses,* there is a clear and precise reference to Jacob Boehme and to his book, *The Signature of All Things*. Boehme's name is still somewhat familiar to students of theology and philosophy. He is said to have influenced philosophers from Hegel to Heidegger and theologians down to Tillich, Berdyaev, and Marcel. But he has been better known in earlier ages than our own. For those who may not be familiar with Boehme, here is a brief life of this writer in whom Joyce was very interested, and to whom he therefore referred rather more widely in his writings than is generally realized.

Jacob Boehme was born near Görlitz in what is now East Germany in 1575, and lived in that town most of his life. He was a shoemaker by trade, who later sold his shoemaking business to become a draper, and dealer in woolen articles.

Boehme was always very religious, and in his maturity he had two religious experiences which not only colored, but really shaped the rest of his life. Under the influence of these experiences, he felt compelled by God to write down what had been revealed to him, and he wrote so rapidly and compulsively that he has been considered by some critics the first of the "automatic" writers.

As an untrained theologian, however, Boehme got into a great deal of trouble with his pastor and other religious leaders, so eventually he wrote some of his works in the language of alchemy. As Evelyn Underhill puts it, some ancient religious writers used the language of alchemy to convey religious "secrets to the elect, whilst most certainly concealing them from the crowd."[1]

It can already be seen, that Joyce would have found a writer like Boehme interesting because of his hermetic writings as well as his sometimes strange philosophy. Joyce would have seen similarities between Boehme and that old favorite of Joyce's, Giordano Bruno. There were also aspects of Boehme's life as religious rebel, and martyr of a kind, which must have attracted Joyce. So it is no wonder that we find Stephen musing upon Boehme as he says in "Proteus," "Signatures of all things I am here to read . . . ," and goes on to meditate on particular signs as he sees them along the strand.

Stephen's reflections in this section mirror the thoughts of other philosophers besides Boehme. Aristotle is one of these. It is not surprising that this is so, because Boehme's philosophy in his *Signature of All Things* is very similar to Aristotle's. The thinking in "Proteus" is united by many links of associative logic. As the section continues and we see Stephen meditating on Proteus or a Protean God, we go even deeper into Boehme's theories. For the most striking of all Boehme's theories and the one which most interests modern philosophers is that of the evolutionary nature of God.

Boehme actually taught that the Godhead evolved, and in fact, is eternally evolving. This theory seems to be evidenced in Stephen's thinking in this section because no matter what trend his thoughts take, still, by associative logic, he keeps coming back to thoughts of the Godhead, which he thinks of as a kind of Proteus. He muses: "God becomes man becomes fish becomes barnacle goose becomes featherbed mountain." (50:13-14)

Stephen also refers to the Godhead as "Mananaan," the old Irish sea god, and finally as the Demiurge. These references, too, are very much in line with the nature of Boehme's version of God. Mananaan, like Proteus, is a changing God. The term "Demiurge" comes from Gnosticism, and this is related to Boehme because many of his doctrines reflect Gnostic doctrines, just as they do Cabalistic teachings.

There are other aspects of Boehme's doctrines present in the "Proteus" section, such as his ideas of Adam Kadmon, of Lucifer, and so on. The more one knows of Boehme's writings, the more one can see reflected in this episode. Some of these doctrines have implications which continue throughout *Ulysses*. It is, however, in *Finnegans Wake* that one finds the most frequent references to Jacob Boehme.

The Boehme allusions in *Finnegans Wake* are done somewhat in the same manner as Joyce's many allusions to Giordano Bruno. The Boehme usages are part of intricate and amusing wordplays, yet often they are also thematically linked. For instance, one of the main ideas in *Finnegans Wake* is the fall of HCE or Finnegan, which has also been interpreted by many critics as Adam's fall or the fall of Everyman. However, there have been some critics who have seen this as the fall of divinity itself. Atherton, for example, sees it thus.[2] William York Tindall identifies HCE as the God of the Cabala.[3]

Now the idea of a God falling into nature is a Gnostic idea which looms large in the works of Boehme, which is very likely where Joyce met it. There was also a phase of Boehme's development in which he was rather pantheistic. For him, nature was God's body. So HCE's body, scattered all over the landscape fits very well with this conception.

There are a number of symbols which Boehme uses in connection with God that are in turn used by Joyce in marvellous types of word play connected with HCE or with Shaun, HCE's son who seems to supplant or become his own father in some sense, thus becoming God himself. These symbols are the rainbow, flowers, creative thunder, and the number "7".

In Boehme's symbology the rainbow was the throne of God as well as a part of his body. In the *Wake,* too, in the very first pages, we find the "regginbrow ringsome on the aquaface." This is probably a reflection in water of the rainbow, or a reflection of the eyebrow of God, or a reflection of the eyebrow of HCE who is God. There are also the rainbow girls who surround Shaun as he grows in importance. Their presence seems to indicate his growing divinity.

The rainbow girls and Shaun also play the game of "Angels, Devils and Colours." This is very significant because flowers were symbolic of angels in Boehme's theology. Each color revealed the nature it signified. The rainbow girls in this chapter are both angels and flowers.

Boehme also used thunder as a creative symbol in his writings, and said, for instance, that it occurred when the Father first recognized Himself (during the evolutionary process) and then also when the Father recognized His Son. The thunderclap is, of course, also extremely significant in the *Wake.*

"Seven" is an old mystic number which Boehme uses frequently in regard to God, and he uses it in especially significant ways. One of these is the number of emanations in his evolutionary God. Joyce uses the number frequently when referring to HCE and also to Shaun as he seems to become HCE. In one place, HCE is attired in seven articles of clothing.[4] In Chapter 13 Shaun also wears seven articles of clothing.[5] These references all strengthen the claims to divinity of HCE and his son.

There are many other word clues that Joyce makes use of when he embellishes a Boehme theme and even employs in groups by themselves. Such words usually occur within restricted passages or are scattered over no more than a page or two. The kinds of words are all associated with Boehme's life or works. (Incidentally, these symbols can all be found neatly grouped in the Introduction to the Law edition of Boehme's works which was published in England between 1764 and 1781, and which remains the most famous English edition of Boehme's works.)

One of the most important of the symbols just mentioned is the lily. The lily above all is Boehme's sign. Boehme compared union with the Divine to "the scent of the lily," and "the blossoming of the lily." He had a lily engraved on his own signet ring, and a lily also appeared on his grave marker.

Another clue word is ladder. Boehme spoke often of having climbed up a ladder in his soul to where he found his God. The Trinity, the word "three," and even the word "four" are also associated with Boehme. The Trinity is used because Boehme wrote so much about the origins of God, and "four" is used because in his theologizing Boehme was said to have discovered a fourth person in God, a discovery which was always vehemently denied by Boehme. Wool, gloves, shoes, boots, hammering, etc., are all frequent clues, and obviously are all connected with Boehme's trades.

There are also a great many word plays on Boehme's own name. The name is also correctly spelled "Böhme," and in England it sometimes appears as "Boehm." The name is also frequently mispronounced. Joyce naturally makes the most of this, making the name appear as "Bohemia," "Beam," "Bean," and in many other variations. Thus, the words "Lily of Bohemey" which appear in the *Wake* (246:18) and have been taken to mean "The Bohemian Girl," are also a reference to Boehme and his lily. Similar clues can be easily multiplied. These terms, or word clues, are usually employed when Boehme is tied to a theme. So with the HCE/God theme already described, many of these terms also occur.

There are several other themes in the *Wake* to which the Boehme word clues are tied, and other kinds of clues, such as Boehme's given name, Jacob (which is also James and is therefore also Shem) which could be explored more fully. One final point is still to be made. In pointing out Joyce's frequent use of Jacob Boehme in his works, I do not wish to imply that Joyce subscribed to Boehme's doctrines. In Joyce's younger days, when he discovered some of his other favorites—Vico and Bruno, he may have come across Boehme also. At this stage of Joyce's life, he may have been interested in the mystical aspects of Boehme's writings. The young Stephen of *Portrait* exhibits a definite interest in mysticism, however much he may or may not mirror Joyce's own early interests. As a mature adult, Joyce seems to have been interested in mysticism only in so far as he was interested in the arcane, hermetical, or the extremely unusual. Joyce was interested in Jacob Boehme. His interest, however, was as he himself said in regard to Vico, to "use him for all he was worth." Such use, like so many other Joyce uses, has forever enriched *Finnegans Wake* as well as our enjoyment of it.

NOTES

[1] Evelyn Underhill, *Mysticism* (New York: E. P. Dutton and Co., Inc., 1961), p. 142.

[2] James Atherton, *Books at the Wake* (New York: Viking Press, 1974), p. 31.

[3] William York Tindall, *A Reader's Guide to Finnegans Wake* (New York: Farrar, Straus & Giroux, 1972), p. 174.

[4] James Joyce, *Finnegans Wake* (New York: Viking Press, 1971), p. 30.

[5] *Ibid.*, p. 404.

THE LABYRINTH: A FOUNDATION OF CHURCH AND CITY SYMBOLISM

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Novelists commonly describe the city in labyrinthine terms. The changing definition of the term is significant. To the ancients, the labyrinth connoted paths of intricate deviation leading eventually to a center for the initiated from which demons were excluded by the very device of the labyrinth. In the Middle Ages that center still held in the guise of walled towns with a centrally-located church giving order to the whole complex. In the nineteenth century that center begins to be eclipsed by secular institutions and by the twentieth century, novels question even the validity of presupposing that a center exists to be found. Consequently, in considering the interrelationship of church and city, one is led to consider the labyrinth with its circular core as symbolic foundation of the city. Before considering the correspondence between center and periphery, it will be necessary to consider each concept separately in its symbolic uses and meaning. Correlations between the dynamics of the labyrinth and those of the city will then be more apparent.

According to anthropologists, geographers, and psychoanalysts, the geometric concept of circularity is one of the most universal and basic to men's understanding of the world. Universally it is a symbol of wholeness and harmony. It is, according to Yi-Fu Tuan, "a recurrent motif in the arts of ancient eastern civilizations, in the thinking of ancient Greece, in Christian art, in the alchemical practices of the Middle Ages, and in the healing rites of some nonliterate peoples." As an archetypal image of the reconciliation of opposites, the circle also appears in the design of traditional and idealized cities. People everywhere show evidence of structuring space by placing themselves at the center "with concentric zones . . . of decreasing value beyond"; illustrating thereby the universality of center and periphery as organizational concepts. Related to circularity, according to Tuan, are the concepts of open and enclosed. Whereas openness often signifies freedom, adventure, light, and society, closure suggests the womb, security, darkness, and privacy. When one or the other becomes threatening, however, the victim experiences either agoraphobia or claustrophobia.[1]

One of the most ancient uses of the circular as symbol remains even today in the visible traces of burial grounds. As a consequence of studies conducted particularly in England and the British Isles, A Hadrian Allcroft has cited evidence which demonstrates that architectural features of burial grounds for dawn man were most frequently circular. As containers of the bones of the venerated dead, these grounds took on a religious character. Another feature of these circular burial grounds was a vertical image located at the center. Whether tree, rock, or pole, this vertical object served symbolically as a link between heaven and earth, between the mcirocosm of man and the macrocosm of the universe. In short, "religion and burial being inseparable, the same circularity which marked the burial place marked also the *temenos;* tomb and temple had one common plan."[2] Because these grounds became temple sites, the cemetery served as the foundation of the city with the temple as religious and legal center of authority.

The circular burial ground with vertical dimensions, then, was a place of ritual veneration with cosmic orientation. And as such, it represents the bare bones of an architecural structure which eventually received the name church. The word *church* itself shows in its etymology this connection between circularity and consecration. In Old English, *church* is derived from "cirice" meaning circle. Just as burial grounds were set aside, i.e., consecrated for religious ritual by the presence of bones, so too the church altarstone used for the ritual sacrifice of the death-resurrection mystery must contain the bones of a venerated, deceased member. The idea of a plot of ground taking on a sacred character is developed by Mircea Eliade in *The Sacred and the Profane*. According to his thesis, man encountered the world as differentiated: land from sea, and sky from both, for instance. But ways of imposing meaning by categorizing were invented only as part of an historic process. Until these ways of imposing significance evolved, the earth was amorphous, or to use Eliade's term, profane. What designated certain times and places as sacred in opposition to profane, then, was their being differentiated from the mass, set aside or consecrated, as the word sacred implies. Consequently, meaningful assembly with the presiding presence of ancestors in consecrated burial ground came to be seen as a sacred act. Furthermore, since scientific findings have established the circular burial ground as the first meeting place chosen because of its sacred character, burial ground bears a real relationship to the structure later known as the church. Even after circularity disappeared as a common feature of burial grounds the dead continued for some time to occupy the area immediately surrounding the church. This practice remains even today in country churches. Similarly cathedrals entomb their venerated dead beneath the nave. The practice of burying the dead around city churches was discontinued for practical rather than symbolic reasons. There simply was not enough land available and people recognized the danger to their health. Nevertheless, the notions of church and cemetery remain closely associated culturally even today. For modern churches without crypts still have bones in their altarstones and often in their cornerstones.

Because circularity has always been associated symbolically with perfection and the vertical with transcendence, it is appropriate that these geometric shapes be incorporated into the church with its orientation in the supernatural and absolute.

Circularity is associated symbolically with the ideal city as well as the ideal church, however. And in fact, the two are often associated together as one large circle: the church as the center, the city organized concentrically around it. According to Lewis Mumford, the city had its birth in the burial ground, just as the church did. "Urban life," he writes, "spans the historic space between the earliest burial ground for dawn man and the final cemetery, the Necropolis, in which one civilization after another has met its end."[3] Like the church, then, the ancient city received its birth and special character from the burial ground that constituted its center.

Examples of circular cities founded on burial sites are still with us in the world of fact as well as fiction. Rome, for example, was supposedly circular at its founding "with the *mundus* (the place of departed souls) at the center."[4] Even today Rome is called the Eternal City because it is the reputed seat of Christ's vicar on earth and capital of Christendom. This city derives its greatest significance, then, from its being the center of the universal church. Moreover, St. Peter's Basilica was built on a cemetery; and tradition has it that the basilica was built over St. Peter's tomb.[5]

One must also consider Jerusalem, which was placed at the center of the world in medieval maps. The wheel maps of the Middle Ages, with Jerusalem located at the hub of the wheel, "expressed the beliefs and experiences of a theological culture."[6] This city, like Rome, is also envisioned as a church in its designations as "Heavenly Jerusalem," "New Jerusalem," and "City of God." Moreover, medieval man depicted the temple of Jerusalem at the center of a circular walled city.

Circular models also guided the founding of relatively recent cities in history. Paris, for example, was "concentric in pattern and focused on the Cathedral of Notre Dame on the Isle de la Cite."[7] Other medieval cities circular in topographical orientation and in which the cathedral occupies a central location include the following: Toulouse and Limoges in France; Cologne, Hanover, and Frankfort-am-Main in Germany; and the cities of Buda in Hungary and Vienna in Austria. In most instances, the medieval city core included the presence of a cathedral or church. For the word "cite" or city "referred to the initial ecclesiastical nucleus."[8] These churches, in turn, were either founded on burial sites or enclosed relics of the dead after the structures were completed. Although the foundations of London, laid before the Middle Ages, are not circular, St. Paul's original cathedral was built on a Roman burial site as a matter of intent rather than convenience, according to Tuan.[9]

In the world of philosophical and theological speculation, Plato's utopia as well as St. Augustine's City of God are based on circular plans. The former combines the circle with the square, while the latter is purely radial. Literary cities portrayed as circular, often with church as center, expressed man's desire to translate heaven to earth. For example, in Marcel Proust's *Remembrance of Things Past,* the town of his childhood is remembered as resembling a medieval town "as scrupulously circular as that of a little town in a primitive painting."[10] Patterned on the image of perfection, the city ideally was to transcend the vagaries of life and reflect the predictability of the cosmos.

Often, too, these cities were surrounded by circular walls which, before they were used for defenses, were designed to suggest completeness. While signifying wholeness, walls also served to fix the limits of the city. Within these walls, man's life acquired a sense of direction and purpose. According to Yi Fu Tuan, "the wall was the clearest expression of what the city builders took to be the limits of their domain."[11] Mumford also emphasizes that walls were used as constructions for defense purposes only late in their history. He also cites the importance of church bells in determining the city's limits. Beyond their sound, one was also beyond the city's boundaries and in that area designated as profane.

Contrary to present day attitudes that idealize the country, medieval conceptions idealized the city. According to a German proverb of the Middle Ages, " 'City air sets a man free.' " To philosophers of Aristotle's time and after, the city stood for a perfect society. Heathens lived in the country or on the heath; peasants (pagus) or pagans lived in the rural districts.[12]

Combining the horizontal and the vertical, the circular city aspired toward an order based on the vault of heaven itself, and in its aspiration came to symbolize that order. In the same way, the church was also viewed as image of the cosmic order. In Byzantine church architecture, for example, the vault of the church was an image of heaven with the floor as paradisiacal earth. The dome as vault of heaven was preserved through Renaissance and into modern times. Public gestures of man's desire for the transcendent, expressed by the church in ziggurat, pyramid, steeple or temple, has its counterpart first in the church as the center, then in its monument and fountain at lesser "centers." With their vertical-horizontal tension united in the circle construct, city and church symbolize the "antithesis between transcendence and immanence, between the ideal of disembodied consciousness (a skyward spirituality) and the idea of earth-bound identification."[13] A sense of vertical striving is tempered by a horizontal call to rest.

Both church and city, then, acquired their rudimentary beginnings within the circular burial ground as place of religious ritual and communal assembly. The labyrinth stands in conjunction with circularity as well in its combination of the vertical and horizontal, signifying perfection. Although not all labyrinths of fact or fiction are circular in shape, the ritual dance associated with them always includes circular movement, indicating their basically circular nature. The general construction of the labyrinth consists of a central area circular in form surrounded by a series of concentric, winding paths intended to confuse the uninitiated.

According to the myth of Theseus,[14] which expresses the mythico-religious significance of the labyrinth, the center was a sacred space. Within it, the Minotaur (half-man, half-bull) signified the union of mortality and immortality (the bull being a symbol of divinity for the ancients). In slaying it, Theseus performed an act of defiance even while fulfilling a requirement of a religious cult. According to this cult, it was necessary that the bull, surrogate for the king-god, be slain in the king's stead, thus insuring the king's continued life as well as the lives of his subjects. Like the ambiguous nature of the Minotaur (god-man) as well as the labrys (double-bladed axe) with which Minotaur was slain, the myth has a double interpretation. According to one theory, Theseus performed a saving act by slaying the Minotaur because in doing so he guaranteed the peoples' lives.[15] In another interpretation, however, Theseus was a usurper in that he embodied the Greeks' hatred of the Cretan bull-cult.[16] By slaying the Minotaur he symbolically destroyed that cult, displacing it and substituting that of Athena and the cult of the ram.

Whatever the correct interpretation, it is clear that the labyrinth itself was a center of religious ritual; that it was circular in structural orientation; and that it celebrated the death-resurrection mystery in a fertility cult. In all these elements it resembles in nature and function a role later played by church and city. Like the church as locus of the celebration of life and death mysteries, the labyrinth was the locus of man's attempt to "overcome death and renew life." According to C. N. Deedes, it was in the labyrinth that "the living king-god went to renew and strengthen his own vitality by association with the immortal lives of his dead ancestors."[17] Communion with the dead was also the purpose behind burial rites celebrated on burial sites. Evidence in the remains of stone circles in England and the Scandinavian countries demonstrates the relationship between circular burial ground and labyrinth: "When we come to examine some of the stone circles of Scandinavia," writes Deedes, "we find that they are actual labyrinths, conforming in design to the plan of those on the coins of Knossos."[18]

While burial ground and labyrinth are clearly related as just demonstrated, city and labyrinth are also closely related conceptually as well as actually. These relationships are the links of a chain, then, joining labyrinth to church and church to city, circularity being the common feature uniting all three. One link, however, remains dangling by itself unless the following question is answered: what is the relationship between city and labyrinth?

The labyrinth, related as it is to church through its association with burial ground, has a more direct relationship to church as well as city in its medieval representation in cathedrals themselves. As W. H. Matthews has pointed out, medieval churches contain labyrinths in art on floors and walls. While some are called "ways," others have the name "Jerusalem" inscribed at their centers. A labyrinth has also been found with the words "Sancta Ecclesia" at its center. Conjecture is that these labyrinths served as miniature pilgrimages to holy cities for those who could not make the actual trip. A "Chemin de Jerusalem" could be walked with one's index finger on the wall if one could not traverse the roads on foot.[19] Not only the church, but the city as well began as a magnet drawing people together to celebrate mystery; the city, too, was "the goal of pilgrimage."[20]

Various pseudonyms for labyrinths also establish a connection between them and cities; "Ruins of Jerusalem," "City of Nineveh," "Walls of Jericho," and "Babylon" are some of the names given to labyrinths.[21] According to legend, Ariadne's dance was performed in Troy, and in fact was responsible for the city's fall in that, while the dance was being performed around the walls, the Greeks wheeled their wooden horse through its gates. The notion of troia ("a winding") was then carried as far north as Scandinavia where it survives as a labyrinthine maze in earthworks and stone circles. Labyrinth and city are notions related to each other, then, through Troy, a city whose name indicates the labyrinthine.

Not only are labyrinth and city joined by historical evidence; the two are related conceptually as well. A tension between exclusion and inclusion characterizes both labyrinth and city. While the labyrinth's inner winding passageways promise the possibility of extension, its external windings protect the center from violation by the uninitiated in the same way that the burial place was protected from grave-robbers by intricate passages. According to Paul Kuntz, "the labyrinth was able to protect a city, a tomb or sanctuary, but in every case, it protected a magical-religious area which excluded those not invited or initiated."[23] The center was a place secluded, while the periphery protected it from invasion.

Besides the tension between exclusion and inclusion, labyrinth and city embody a similar tension between injunction and permission. While injunctions take shape as laws designed to protect the community and regularize worship, permissions contain the more vital designation of possibilities and freedom. Exposure and seclusion, permission and injunction, then, are some of the psychological dynamics of the architectural construct of both city and labyrinth, each with its sacred core surrounded by peripheral deviations.

For the city this core often took the shape of a citadel with its law court and temple; for the labyrinth, it was bull-ring of ritual celebration. Just as cities often had circular walls enclosing them, the labyrinth had "a circular crenelated enclosure."[24] Related to both city and labyrinth, the injunctive nature of laws as reflected in visible walls, served to define the interior space of city and labyrinth as sacred or set apart. Citadel and center asserted symbolically man's desire to overcome death, to unite heaven and earth, to join the transcendent and the immanent. In their life-giving powers labyrinth and city were a common "means of bringing heaven to earth."[25]

NOTES

[1] Yi-Fu-Tuan, Topophilia: *A Study of Environmental Perception, Attitudes, and Values* (Englewood Cliffs: Prentice-Hall, 1974), p. 17.

[2] Hadrian Allcroft, *The Circle and the Cross* (London: Macmillan, 1930), I, p. 22.

[3] Lewis Mumford, *The City in History: Its Origins, Its Transformations, and its Prospects* (New York: Harcourt, Brace, and World, 1961), p. 7.

[4] Tuan, p. 153.

[5] *Encyclopedia of World Art, VIII* (London: McGraw-Hill, 1962), pp. 324-349; 527.

[6] Tuan, p. 41.

[7] Tuan, p. 159. For geometric significance in town planning see John Archer, "Puritan Town Planning in New Haven," *Journal of the Society of Architectural Historians,* 34 (May 1975), pp. 140-149.

[8] Robert Dickinson, *The West European City: A Geographical Interpretation* (London: Routledge and Kegan Paul, 1951), p. 252.

[9] T. G. Bonney, *Cathedrals, Abbeys, and Churches of England and Wales* (London: Cassell and Co. 1891), p. 44.

[10] Marcel Proust, *Swann's Way,* trans. C. K. Scott Moncrieff (New York: Modern Library, 1928), p. 59.

[11] Tuan, p. 230.

[12] Tuan, p. 150.

[13] Tuan, p. 28.

[14] Works consulted regarding the myth of Theseus and the Minotaur include the following:
Apollodorus, The Library, 2 vols., trans., James Frazer (London: William Heinemann, 1921).
Michael Ayrton, *The Maze Maker* (London: Longmans, Green, and Co., 1967).
Ronald Burrows, *The Discoveries in Crete* (London: John Murray, 1908).
Diane De Turo Fortuna, "The Labyrinth of Art," Diss. Johns Hopkins Univ., 1967.
Edith Hamilton, *Mythology* (New York: New American Library, 1942).
Ovidus, *Metamorphoses,* trans., Sir Samuel Garth (New York: Heritage Press, 1961).
Plutarch, *The Lives of the Noble Grecians and Romans,* Vol. I, trans. Thomas North (Oxford: Basil Blackwell Press, 1928).
Louis Herbert, ed. *Mythology of All Races* (New York: Cooper Square Publishers, 1964).

[15] Phillippe Borgeaud, "The Open Entrance to the Closed Palace of the King: The Greek Labyrinth," in Context," *History of Religions,* 14 (August 1974), p. 1-27. Also, S. H. Hooke, ed., *The Labyrinth: Further Studies in the Relations Between Myth and Ritual in the Ancient World* (New York: Macmillan, 1935), ix.

[16] C. N. Deedes, "The Labyrinth," in *The Labyrinth,* ed. S. H. Hooke, p. 29.

[17] Deedes, p. 42.

[18] Deedes, p. 38.

[19] W. H. Matthews, *Mazes and Labyrinths: A General Account of Their History and Development* (London: Longmans, Green, and Co., 1922).

[20] Mumford, p. 10.

[21] Matthews, p. 56.

[22] Deedes, p. 6.

[23] Paul Kuntz, "The Labyrinth," *Thought: A Review of Culture and Idea,* 47 (Spring 1972), p. 11.

[24] Deedes, p. 6.

[25] Mumford, p. 31.

AFRO-AMERICANS IN EARLY WISCONSIN

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The Upper Great Lakes Territory, later to evolve into the states of Wisconsin, Michigan, Illinois, Indiana, Ohio, and part of Minnesota, became a home for Africans and their descendants almost from the time of its discovery. In their efforts to develop this territory, the French established trading posts as well as military and religious settlements. Their purpose, like that of the English to the South, was to establish a source of economic resources that would be channelled back to the coffers of Europe.

Soon after their entry into the territory, the French added to the soldiers, missionaries and envoys some 500 Africans from Guinea, West Africa.[1] These Africans constituted a substantial portion of pioneers as the French moved deeper into the Mississippi Valley. Within five French settlements along the Mississippi, i.e., Kaskaskia, Kaaki, Fort Chartres, Saint Phillipi, and Prairie de Roche, well over 300 Africans were counted along with the 1100 Europeans, indicating that Africans comprised nearly twenty percent of the population in the Mississippi territory.[2]

While Africans served as sources of population and labor for the New World, the French had apparently not concluded that Africans were to be treated solely as property with little ability to make decisions over their lives. Therefore, Africans functioned in many of the same capacities as the French. Records indicate that Africans, like the French, served as fur trappers and traders, as packhorsemen, cooks, and voyageurs. According to the hierarchy among the French, groups of traders were formed with a chief trader responsible for collecting the goods and furs and seeing that these were transported to New France and Canada for exchange. A number of these chief traders and entrepreneurs were known to be Africans.[3]

Although Africans were accepted as free agents in trading roles, they were also used as slaves, especially by those who appeared to be of some social importance. For example, in the early 1700's a French priest recorded the baptism of Charles, a Negro slave of M. de Vercheres, the commandant of one of the military posts established by the French within the territory.[4] Similar records note the presence of other slaves in the homes of wealthy traders.

Exactly how the French were able to reconcile the contradictory roles assigned to Africans in the same territory is not clear. From all indications, however, they did not appear to limit contact between the two groups, for records indicate several instances of independent voyageurs and fur traders marrying slaves. One such incident is that of Bon Coeur, a French-American fur trader, who married Marguerite, also known to be of African descent.

According to the records, Marguerite was travelling through the Great Lakes territory with her master, Sieur Boutin, on their way to one of the settlements in Illinois, when she met Bon Coeur. As love would have it, they were soon married by a French priest and a year later had a daughter, Veronique, who was baptized in 1743. Exactly how this marriage affected the slave status of Marguerite is open to speculation. The baptismal records seem to indicate that all three members of the Bon Coeur family became the slaves of Sieur Boutin; however, there is also evidence that Bon Coeur remained a fur trader and continued his work among the Indians.[5]

The population of the Upper Great Lakes area did not remain stable. Although the French were the dominant residents of the territory between 1687 and 1763, numbers of British fur traders and settlers also resided in the area. During the French & Indian War, the French and British fought numerous battles over the right to control the territory. By the treaty which ended the war in 1763, the British gained control of the area, Canada and the upper Mississippi. Unwilling to become British subjects, many of the French settlers and their African counterparts migrated down the Mississippi and established a fur trading post around the St. Louis area. According to Moses Strong, this migration consisted of approximately 2500 people, of which 900 were Africans.[6]

This rather large emigration from the territory left few African-Americans; not many more were to come with the British. This was but the first of several population drops during the development of Wisconsin which helped generate the myths that: (1) African-Americans could not tolerate the climate of these extreme northern states, and (2) Wisconsin has not had a sufficient African-American population to warrant investigation of their historical contributions.

Those African-Americans who remained in the territory were independent fur traders who lived and worked among the Indian tribes, slaves of Frenchmen who chose to stay, and Africans who had intermarried with French settlers. Among these French African-Americans who remained in the territory were two individuals who later figured prominently in the settlement and development of Wisconsin, Illinois, and Minnesota. They were Joas (Jean) Bonga and Jean Baptiste Point de Sable.

Joas (Jean) Bonga or Bunga, though later listed as free, was said to be a slave of Captain Daniel Robertson, the British officer in command at Mackinac between 1782 and 1787. There are indications that the French chose to sell their slaves to the British, but historians have speculated that Bonga was acquired by the British officer from Indian traders who had previously captured him from the French around Missouri during the Revolutionary War.

Upon joining the Robertson household, Joas met and married another Robertson slave, Marie Jeanne, also of African descent. To Marie Jeanne and Joas were born two daughters, Rosalie in 1786 and Charlotte in 1782.[7] Historians have placed a great deal of emphasis on the fact that Joas and Marie Jeanne did not marry until 1794, which meant that their children were illegitimate.[8] It should be noted, however, that the relationship between Joas Bonga and his wife was not very different from those of other fur traders in the area, British and French included. As pointed out by Louise Kellogg, fur traders were required to live far from the posts to carry on their business with the Indians.[9] Within the territory surrounding the trading posts, there were few priests, and it was not until one became available that a couple chose to repeat their vows of marriage—often after years of living as man and wife. This may very well have been the case with the Bongas.

Bonga descendants became prominent in the development of Wisconsin, Michigan, and Minnesota. A son of Joas and Marie Jeanne, Pierre Bonga, followed his father's footsteps and became a successful trader among the Chippewas, as did the grandson, George Bonga. It was apparently this George Bonga who served as an interpreter to Governor Lewis Cass in the treaty negotiations with the Indians at Fond du Lac in 1820.[10]

Among those free Americans of African descent living with the Indians in the territory was Jean Baptiste Point de Sable. De Sable came to the Northwest Territory and established himself as an independent fur trader. There are various theories about his point of origin, some claiming that he came from the West Indies, others suggesting that he was a runaway slave from Kentucky. As an independent trader, he set up a trading post among the Indians in 1779 on the site that was to become Chicago, Illinois.

By 1783, the newly formed federal government of the United States had obtained control of the territory around the Great Lakes and had taken over the fur trading industry. Because the numbers of Africans, both West Indies and native born, had increased to the point where half of the population of some southern states had become African-American, and because the issue of slavery was becoming a rather complex problem that the new government did not wish to deal with, some consideration was given to colonizing the new territory with the new African immigrants.[11] This idea was abandoned when the states decided it would be better to contain the people of color and slavery in the southern region. Apparently it was assumed that transportation of the Africans would mean the establishment of the institution of slavery in the north. Thus, in the ordinance establishing the Northwest Territory a clause was included prohibiting slavery or involuntary servitude of any type. This must also have meant that there were to be no Africans, for a few years later the congress passed the Fugitive Slave Act of 1793 which forced the return of slaves reaching the territory on their way to Canada and freedom.

The effort to exclude African-Americans from the Northwest Territory was not successful. There were, of course, some Africans still residing in the territory, having come with the French. Others arrived as runaways and to avoid recapture found it often to their advantage to settle with the Indians in the area. As had occurred during the French regime, many interracial marriages took place and, finally, cultural absorption. One of the best examples of this is the LeBuche-Duchouquette-Gagnier-Menard family.

In the early years of the Northwest Territory, two settlements existed in the area that was to become Wisconsin—Prairie du Chien and Green Bay. These two settlements developed largely because they were close to the military posts established to help settlers in the area, to fight Indians, and to maintain control over the fur traders remaining in the region. Of the two, Prairie du Chien was apparently the larger. In his recollection of the early days at this settlement, James Lockwood wrote:

> Among the other inhabitants of notoriety at that time was a Mrs. Menard, of mixed African and white blood. She came from one of the French villages below and then married to Charles Menard, a Canadian of French extraction. She had been married twice previously. . . .[13]

Mary Ann LeBuche, or Aunt Mary Ann, as she was known, served as a midwife, nurse and healer. From all indications, her obvious African features created no difficuly for her. During her lifetime, she bore 13 children to three husbands. She and her first husband, Duchouquette, a Frenchman, had two sons. Of the sons, Francois DuChouquette is mentioned in historical notes of John Jacob Astor's expedition to the mouth of the Columbia River. After DuChouquette, Aunt Mary Ann married Claude Gagnier, also French, by whom she had three sons and three daughters.[14]

The Gagnier children evidently became respected citizens of Prairie du Chien and participated in the community with little difficulty and little discrimination. It was recorded that one of the boys was a blacksmith while the others became wealthy farmers.

Registre Gagnier, one of these latter sons, figured in a significant historical event of the time. He resided on his farm approximately three miles from Prairie du Chien, together with his wife, two children, and a hired man by the name of Lipcap. As the story goes, Chief Red Bird of the Winnebagoes arrived at Fort Crawford in Prairie du Chien, determined to avenge some insults suffered by members of his tribe. When his efforts to provoke a fight were not successful at the Lockwood trading post, Red Bird and his companions went to visit the Gagniers, friends of his for many years. After accepting Gagnier's hospitality, Red Bird surprised his host and shot him. At the same time, Wekuw, another Winnebago, shot the hired hand. Mrs. Gagnier and her ten-year-old son managed to get away, but the 18-month-old daughter was captured, stabbed and scalped. Surprisingly, the child lived.[15]

Red Bird and his associates were pursued by Colonel Henry Dodge, who later became the territorial governor of Wisconsin, and by soldiers from Fort Howard. Although Red Bird died in prison, his associates were tried, sentenced and afterward pardoned on condition that the Winnebagoes would turn over to the United States their rights in the lead mining area—the land that was to figure prominently in the economic development of the State of Wisconsin.

Gagnier was not the only African-American to die in this uprising. After killing Gagnier, Red Bird and his companions returned to a small settlement of Winnebagoes who had camped at the mouth of the Bad Ax River. During the celebration which followed, several keel boats came by on the way to Prairie du Chien with supplies. The keel boats were attacked by the Winnebagoes and one man was killed—". . . a little Negro named Peter."[16]

The most hostile, conflict-ridden and perhaps most emotional period in the history of America occurred between 1800 and 1865. For African-Americans it was a period in which their difficulties intensified, the search for freedom became an obsession and the institution of slavery was finally abolished. It was during these years that Wisconsin moved from frontier to territorial status and finally became a state. For Wisconsin, as for the rest of the nation, the need to make decisions about citizens of African descent was a major consideration, and led to some of the state's most important moments in history.

With the opening of the Erie Canal and the promise of fertile land for farming, settlers from New York, Maryland, Vermont and other Northeastern states joined foreign immigrants in the Northwest Territory. They brought their belief in the need for an open-labor market with free labor, and the associated view that slavery should be abolished. These individuals settled primarily in the Eastern part of the state. At the same time, from the states of Missouri, Kentucky, Tennessee and Virginia came another group of migrants interested not only in farming, but also in the wealth of the mines. These settlers brought their human chattels and a different set of beliefs about people of color. The largest number of slaveholders and others sympathetic to slavery settled in Western Wisconsin.

The census of Wisconsin Territory in 1840 listed 185 free African-Americans and eleven slaves. At this time the original four-county census had grown to thirty-two counties, with African-Americans residing in sixteen of them.[17] The majority of free African-Americans lived in Grant, Iowa, Milwaukee, Calumet, and Brown counties. The slave population was found in Grant County, where ten slaves—three males and seven females—resided, and in Iowa County, where there was one male slave.

The presence of these slaves stimulated a statewide controversy. Those who favored slavery continued to maintain their property in spite of the fact that to do so was considered illegal under the Northwest Ordinance. Slaveholders included such prominent men as territorial Governor Henry Dodge, his son-in-law William Madden (Chaplain of the territorial legislature), James Morrison, George W. Jones, and James Mitchell.[18] Those who opposed slavery were led by the crusader Reverend Edward Mathews, representative of the American Baptist Home Mission Society. The pressure applied by Reverend Mathews and his followers stimulated all the slaveholders in the state with the exception of James Mitchell, a Methodist minister, to emancipate their slaves, but in name only. Thus, by May of 1848, all slavery was abolished and Wisconsin was admitted to the Union as a free state.

Elimination of slavery, however, did not insure full citizenship to African-Americans in Wisconsin. The state constitution, developed at a convention with no African-American delegates, granted the right to vote to all citizens who were male, twenty-one years of age or older, and residents of the state for one year. This ruling was interpreted as designating only those males who were foreign or native-born Europeans and those Indians who were citizens of the United States but not members of a tribe. Voting rights would be granted to other citizens, namely African-Americans, only if Wisconsin voters agreed.[19]

In addition to those denying the African-American the right to vote prior to the civil war, laws were also passed excluding anyone of African descent from serving in the state or community militia or on neighborhood road crews. According to the Highway Act of 1849, a poll tax payable in labor was required of all male inhabitants of the state except those of color and paupers, idiots and lunatics.[20]

African-Americans in Wisconsin, were however, accorded some legal rights, among them the right to: 1) hold private or public meetings; 2) testify in courts against whites; 3) seek redress of grievances through the courts; 4) own or purchase property; 5) travel without restrictions; 6) seek a free public education; 7) serve on juries; 8) marry interracially; and 9) work in an occupation.[21] When compared with the laws of the surrounding states, Wisconsin's acceptance of African-Americans appeared to be liberal. Ohio, Indiana, Illinois and Iowa, for example, had developed laws governing African-Americans that closely resembled the Black Codes in the South. Although they fared better in Wisconsin, the African-Americans of the state decided that they must have the right to vote and, with the assistance of members of the Euro-American community, set about to obtain it.

Securing the right to vote for citizens of African descent required several state-wide referenda and finally a court suit. The first referendum on the issue, held in 1847, was defeated by the exclusively European-American electorate by a two-to-one margin. As might be expected, the largest number of votes in favor of granting the right to vote to ctizens of African descent was cast in the state's eastern countries and most opposing votes came from the western portion of the state. Citizens of the Madison and Dane County area voted overwhelmingly against granting suffrage.[22]

In 1849, another referendum on the issue was held. After some rather emotional debates, the Second State Constitutional Convention in Madison empowered a new state legislature to grant "colored persons" the right to vote. There was, however, a stipulation that this could be done only if a majority of the votes cast in the particular election were in favor of the proposal. This stipulation proved to be a tremendous barrier, since the vote in favor of granting suffrage to African-Americans was only 5265 out of a total of 31,000 votes cast in the election. The State Board of Examiners, therefore, declared the issue defeated.[23]

The issue was again an important question for voters in the 1857 general election; and again it was defeated. The disenfrancisement of the African-American citizen continued until 1866, when a court suit initiated by Eziekiel Gillepsie, a Milwaukee citizen, resulted in declaration of the election results of 1849 as valid.[24]

The questions surrounding the role of

citizens of African descent in American states and cities created the same emotional fervor and divisiveness in Wisconsin as it did in other geographical regions. For the most part, the division appeared to have regional and geographical bases. Those in favor of full equality were located largely in the eastern portion of the state, where immigrants from non-slaveholding states had settled; and those who held the most ardent anti-black views were found in the western counties. The philosophical differences on the issue became even more pronounced as the debate on slavery and equality reached a fevered pitch throughout the country.

Euro-American rejection of the African-American as a social being and citizen heightened in 1861. As the Civil War loomed, white Wisconsinites, and Dane County residents in particular, became increasingly concerned about the possibility of African-Americans migrating to their cities and farms in greater numbers than ever before. This concern soon generated several attempts to pass laws similar to those of Ohio, Indiana and Illinois that would exclude, or at least restrict, the migration of African-Americans in Wisconsin.[25]

The first effort in this area was the introduction of a Negro Exclusion Bill in 1862 by Saterlee Clark, a Democratic senator from Dodge County. This bill would have dictated that: "(1) no blacks would be permitted to enter Wisconsin after August 1, 1862; (2) circuit courts would have to register blacks already residing in Wisconsin; (3) those blacks already residents would have to carry a certificate which proved they resided in Wisconsin prior to the August 1 deadline; (4) no one could contract for any additional blacks or mulattos to come into Wisconsin to work; and (5) a $50 fine would be levied against any black who arrived illegally or any person who hired them."

The bill, as proposed, was defeated. However, in October, 1862, as refugees from the South began to arrive in Wisconsin from camps in Illinois, the issue was again joined, and noted white Madisonians led the fight. Among these leaders were the editors of the Wisconsin *Daily Patriot,* S. D. Carpenter and Horace A. Tenney. These gentlemen contended that Wisconsin must forestall the migration of the African-Americans, for they would come into the state, take jobs as laborers or domestics, and soon consider themselves equal to white laborers. If this happened, they claimed, Negroes would "eat the bread of whites and white trash would end up standing aside for the 'colored gentry.'" Such a situation was seen as absolutely untenable. Such equal treatment, according to Edward G. Ryan, leader of the Wisconsin Democratic party, went against the principles on which America was founded. As far as he was concerned, America was in the possession of the "white race," and the government of the country was designed to be carried on by "white men for white men."

The dangers of "black migration" to Wisconsin became so controversial that Peter Deuster, a German immigrant and the editor of the *Milwaukee Seebote* used the issue in his campaign and was elected to the State Assembly because of his promise to see that African-Americans were not allowed into Wisconsin. Soon after his election, he introduced a resolution that called for their exclusion. His reasons for asking for this restriction were that:

1. Blacks coming to Wisconsin would end up being injurious to white labor in that they would take jobs white men should have.
2. Blacks given such jobs would take positions from whites who had gone off to fight for the Union; therefore, it was the duty of the legislature to protect the jobs and homes of those soldiers.
3. Blacks should also be excluded because, if permitted to migrate to Wisconsin, they would soon become destitute and end up in the poor house or jail.

Although the Deuster resolution was killed by being sent to a committee which refused to report it on the floor, its language and presentation represented the mind set that was to deny African-American equality again and again.

In 1863, the state legislature began to receive petitions asking it to act again on a Negro exclusion bill. As a result, the third attempt was made through a legislative committee formed to study the issue. In his account of this incident, Edward Noyes suggests that the petition campaign that prompted this third effort was connected to the formation of Democratic Clubs across the state under the auspices of the Knights of the Golden Circle. But regardless of their origin, the petitions came into the legislature and contained the names of prominent citizens of Wisconsin as well as those of poor and recent foreign-born immigrants. One signer was George William Featherstonhaugh, Jr. who was the first signer of the Wisconsin Constitution in 1848—a constitution which had as its first article that all citizens of Wisconsin were free and equal. Dane County and Madison, in particular, presented the second largest number of petitions, only slightly fewer than Dodge County.

The legislative committee responsible for reporting on exclusion suggested that, in the interest of fairness and equality, nothing should be done. In their opinion, all individuals had a right to be judged on their own merits and to move about America as they pleased. In spite of their report, a minority opinion was issued by Oscar F. Jones from Dodge County and a third Negro Exclusion Bill was introduced. The provisions of this bill would: (1) make the exclusion act not applicable to *bona fide* African-American residents of the state; (2) fine any person or corporation bringing an African-American into the state a sum of $200; (3) make all employers of African-Americans furnish a surety bond. The bill also specified that if an African-American became needy or a public charge, the employer would have to forfeit a total of $500 to the city or village in which the African-American lived.

The bill and its substitute was tabled in the Assembly; in the Senate, it was sent to the Committee of Benevolent Institutions where Senators Miles Young of Grant County S. S. Wilkinson of Sauk County led the opposition that resulted in its defeat. Although no further efforts were made to prohibit their immigration, the African-American population of Wisconsin had been served a warning that their presence was unwelcome.

Notes

[1] Woodson, Carter G. *A Century of Negro Migration,* Washington, D.C.: Association for the Study of Negro Life and History, 1918.

[2] Woodson, Carter G. *Ibid.*

[3] Porter, Kenneth. *The Negro on the American Frontiers.* Wisconsin Historical Collections, Volume 11, 207.

[4] Wisconsin Historical Collections, Volume 19, page 11.

[5] Wisconsin Historical Collections, Volume 19, page 9, page 67. Wisconsin Historical Collection, Volume 11, page 204.

[6] Strong, Moses. History of Wisconsin Territory, 1836-1848. Madison: State Printers, 1885.

[7] Wisconsin Historical Collections, Volume 19, pages 83, 91, 97, 157.

[8] Wisconsin Historical Collections, Volume 18, page 497. Porter, Kenneth, *op. cit.,* page 82.

[9] Kellogg, Louise, *The French Regime in Wisconsin.* Wisconsin Historical Collections, Volume 1.

[10] Bennett, Lerone. *The Shaping of Black America.* Chicago: Johnson Publishing Co., 1975.

[11] Woodson, Carter G., *op. cit.*

[12] Gordon, Milton. "Assimilation" in Greer, Colin, Ethnic Experiences in America.

[13] Lockwood, James. *Early times and events in Wisconsin.* Wisconsin Historical Collections, 1903, Volume 2, pages 98-196.

[14] Lockwood, *Ibid.* Porter, Kenneth, *Ibid.*

[15] Wisconsin Territorial Census, 1850. Lockwood's Narratives (1816). Although other individuals of French-African descent intermarried with Indians, the Gagnier-Menard families seemed to marry Europeans in the area, a practice which,

though infusing African blood, soon led to the absence of African identity and color in later gènerations. In fact, in later census records, the members of the family previously identified as having African blood were listed as European Americans or were not given a race identity at all.

[16] Lockwood, James, *Ibid.* Snelling, William M. *Early Days at Prairie Du Chein, and the Winnebago Outbreak* (1867). Wisconsin State Historical Society Collections, Volume 5, pages 146-147.

[17] Wisconsin Territorial Census, 1840.

[18] Carter Clarence, Edwin (Ed), An Abolitionist in Territorial Wisconsin, *Wisconsin Magazine of History,* Volume 52, 1968-69. 3-17.

[19] Fischel, Leslie. Wisconsin and Negro Suffrage, *Wisconsin Magazine of History,* 46, 1963, pages 180-187.

[20] Fischel, Leslie, *Ibid.*

[21] Current, Richard, *History of Wisconsin,* Volume 2, page 146. 1976.

[22] Molstad, John. Wisconsin Attitude Toward Negro Suffrage, Bachelors Thesis, University of Wisconsin, 1900.

[23] Fischel, Leslie, *Ibid.*

[24] Fischel, Leslie, *Ibid.*

[25] Noyes, Edward. "White Opposition to Black Migration Into Civil War Wisconsin," *Lincoln Herald,* 1971, 73, 181-193.

EARLY PROBLEMS WITH LITTORAL DRIFT AT SHORELINE HARBORS ON THE GREAT LAKES

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Abstract

In the mid-1800's, surveys on the Great Lakes documented and commented upon the shoreline changes caused as newly constructed harbor jetties began to interfere with the littoral drift. These jetties caused a predictable pattern of updrift accretion, downdrift erosion, and bar formation at the harbor mouth.

This early work can provide a gauge, or control, of the effects of an isolated littoral barrier on an otherwise natural shoreline. In many areas, modern controls are not available, because shorelines are now extensively modified by engineering works.

INTRODUCTION

At a shoreline harbor, breakwaters and jetties interfere with the normal littoral drift, causing changes in shoreline configuration. The beach commonly advances along the area updrift from the structure; a bar usually forms at the harbor entrance; downdrift shoreline erosion increases so that the shoreline will recede. These problems began to be widely discussed in engineering journals in the last quarter of the nineteenth century (Johnson, 1957). The history of the harbor breakwater at Madras, India, was among the earliest to receive widespread attention (Vernon-Harcourt, 1882; Spring, 1912-1913). However, this paper will show that as early as the 1830's, surveys made along the shorelines of the Great Lakes documented and discussed shoreline changes that were caused by breakwater and pier[1] construction. It is the author's impression that many of these early surveys have been overlooked, possibly because their publication was limited to early government documents.

As settlement progressed along the Great Lakes, it became apparent that there were few satisfactory natural harbors. In most southern areas, the shoreline is regular and smoothly curved. Rivers and estuaries that drain into the lakes were commonly separated from the lake by spits (Eaton, 1828; Stockton, 1838; Cram, 1839). Entrance channels were dredged through the spits, their sides stabilized by jetties, whereupon the littoral drift promptly extended the shoreline lakeward on the updrift side of the jetties and deposited shoals at the channel mouth. Erosion appeared along the downdrift shoreline. Engineers were primarily interested in the maintenance of a navigable channel, so their work on the littoral drift problem was mainly concerned with shoaling and bar formation at the harbor mouth. Engineers debated whether it was feasible to prevent bar formation by extending the piers farther lakeward, or by orienting the piers in a special way, or whether the bar should simply be removed by regular dredging (Graham, 1858a; Cram, 1839). However, some of the shoreline surveys extended for considerable distances updrift and downdrift of the harbor structures, and show an awareness of the effects of harbor structures on littoral processes of the neighboring shoreline. This early work is compatible with

[1] Technically, a pier may be either of open framework or of solid rock, rubble, etc.; the term jetty is more precise in this context, i.e. a solid barrier extended outward from shore into navigable water. However, these were usually called piers on the Great Lakes and that term is used in this paper as synonymous with jetty.

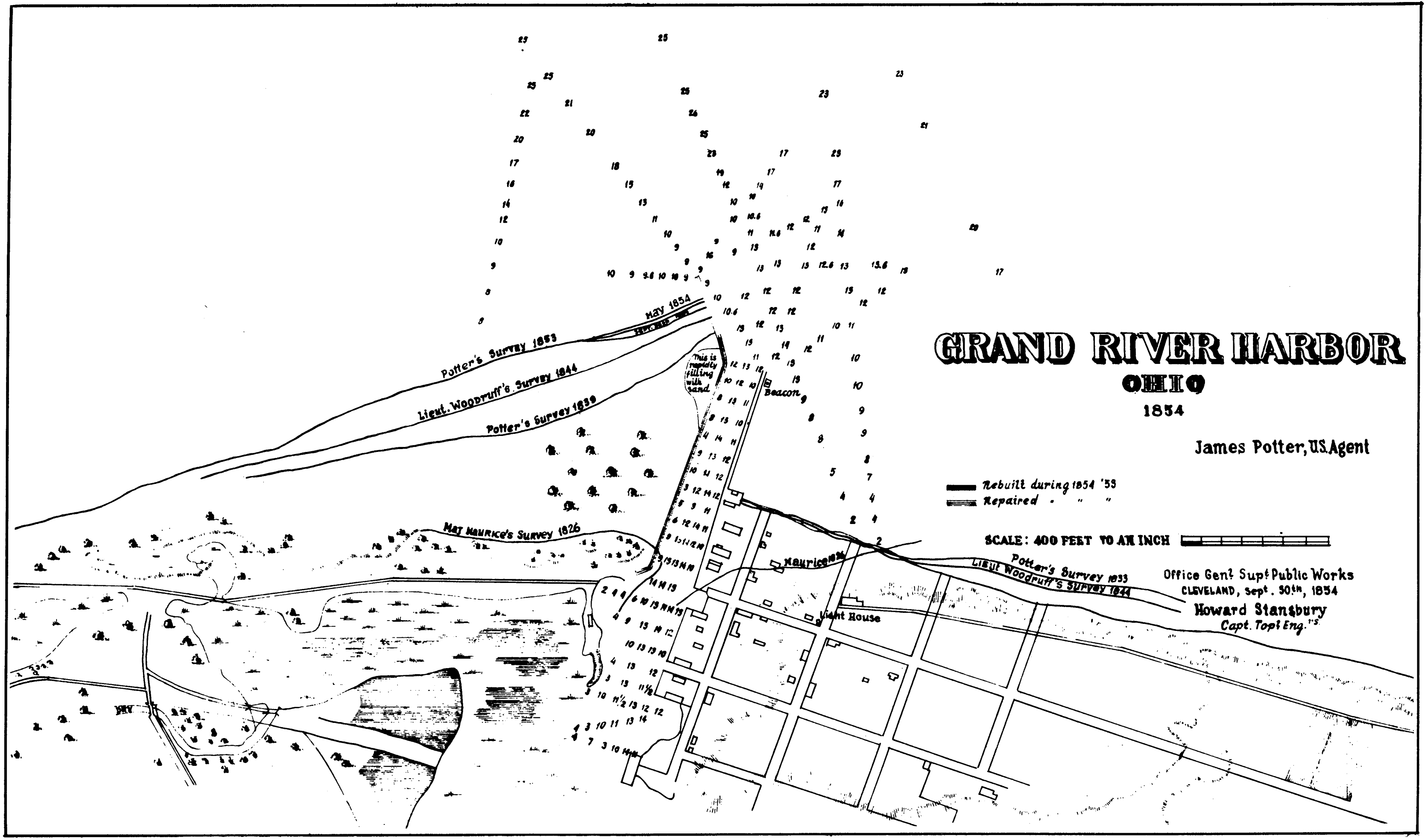

Fig. 1. Grand River harbor, Ohio, 1854 (redrafted from Potter, 1854a). The successive surveys, made from 1826 through 1854, document progressive shore accretion updrift of the piers. Downdrift, a minor zone of accretion trends into a zone of progressive erosion. The full extent of the zone of erosion is not shown.

contemporary understanding of the effects of shoreline structures (e.g. Johnson and Eagleson, 1966; King, 1972; Rosenbaum, 1976), so most of the observations cited will not require extensive comment.

The Surveys

The following surveys were selected for their early date, for their coverage or discussion of the shoreline updrift and downdrift of the harbor structures, or for their depiction of a large number of successive shorelines.

Harbors on the South Shore of Lake Erie:

In a report on harbors along the Ohio and Michigan shore of Lake Erie (Kearney and others, 1839), it was observed that the harbor piers:

> "were commenced within the line of the shore, as it stood when the piers were begun; since which, in nearly every case, the shore has advanced in the direction of the length of the piers-in some cases to no great extent, while in others, especially the more eastwardly of the harbor, the beach has increased very much." (pp. 147-148).

At Grand River, Ohio, the piers:

> "extend beyond the present shore, the west pier 555 feet, and the east pier 635 feet, the beach having advanced, since commencement of the work, 1,180 feet on the west, and 440 feet on the east side of the piers." (p. 180).

and it was noticed that

> "A sand shoal has formed here as at Conneaut and Ashtabula, in advance of the piers, and it has continued to progress with the extension of the work." (p. 180).

First appropriations for harbor improvement at Grand River were made by the Federal government in 1825 (Abert, 1846). A map published in 1854, of successive shoreline surveys (Potter, 1854a), provides a record of progressive effects of the harbor piers (Fig. 1). Surveys were made in 1826, 1833, 1839, 1844, 1853, and 1854. A bar, with depths as little as 2.5 m (7.6 ft.) had formed at the head of the piers. A large area of accretion formed to the west of the piers. A much smaller area of accretion formed to the east, in an area that had been a reentrant near the end of a spit. Farther east, downdrift, the shoreline progressively eroded over the period of record. This zone of erosion apparently extended far beyond the limits of the survey, since the progressive landward displacement of the shorelines is constant, or increasing, at the downdrift limits of the map. Similarly situated zones of accretion and erosion are shown on maps of the harbors of Ashtabula (Potter, 1854b), Conneaut (Potter, 1854c), Buffalo (Pettes, 1854), and Presqu'ile (Williams, 1838). It is interesting that another map of Grand River harbor (Potter, 1854d) is identical to that in Fig. 1, except that the notations "Potter's Survey 1833" and "Lieut. Woodruff's Survey 1844" have been deleted. These notations identify previous shorelines in the area downdrift of the jetties, in which there had been shoreline recession. Conceivably, this omission was an effort to direct attention away from unfortunate consequences of breakwater construction.

Another description of problems with littoral drift is presented in a report of Black Rock harbor (Brown, 1837). This harbor is now a northern extension of Buffalo harbor.

> "The pier which projects from the main shore for the purpose of arresting the sand in its progressive motion along the beach, and preventing it from accumulating in the Black Rock basin, has received no injury. The accumulation of sand against the south side of it, has, however, been so great, that it begins to pass around the outer extremity of the work, and the pier must be extended, or, which could perhaps be more economical, a new one constructed, about 300 yards to the south of it, as was recommended last year, in order to accomplish the object in view. The cause, however, which produced this motion of the sand, is constant and uniform in its action, and I believe that nothing will effectually remedy the evil short of entirely protecting the shore between Buffalo

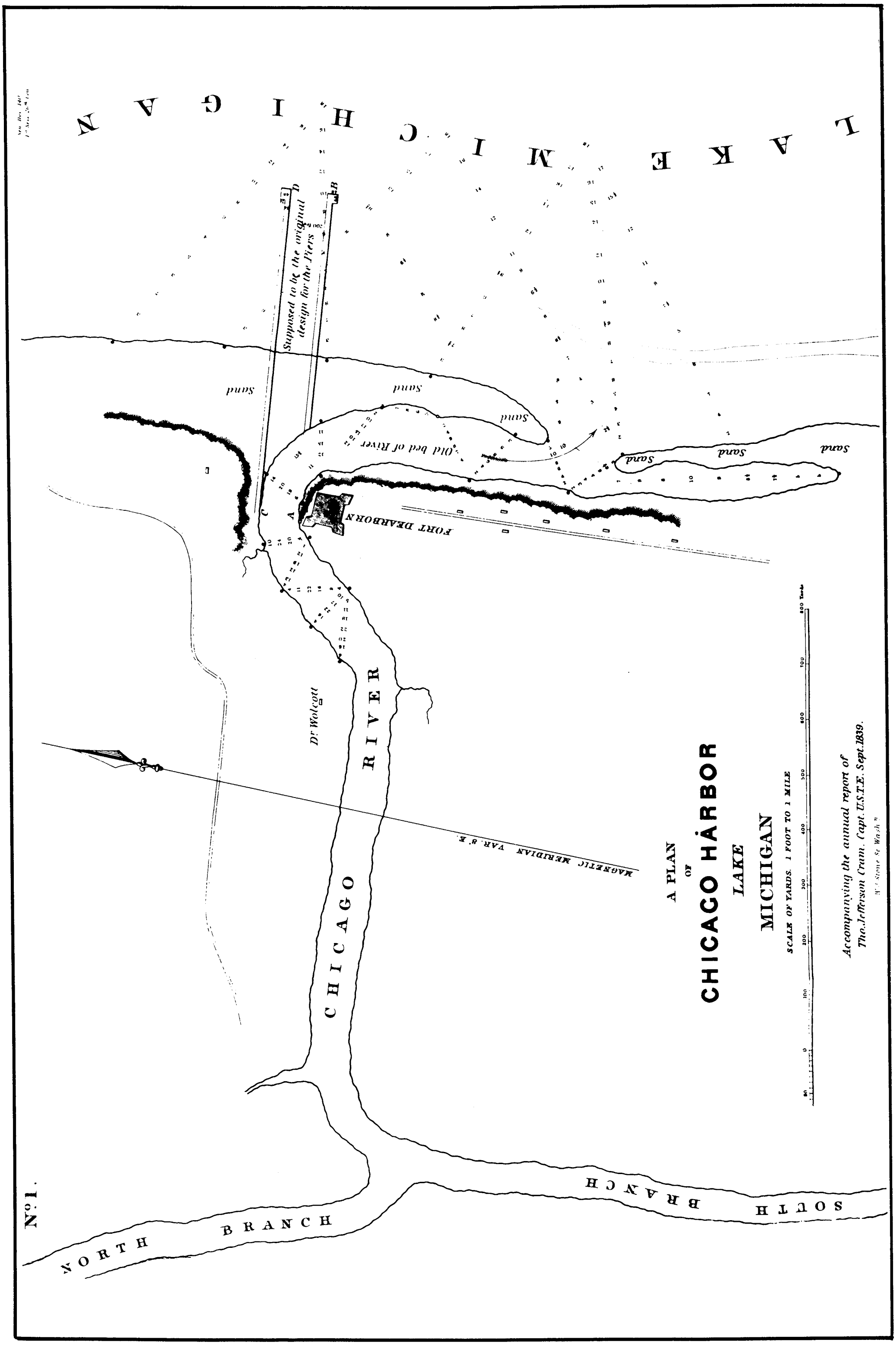

Fig. 2. Chicago harbor (Cram, 1839) before first pier construction.

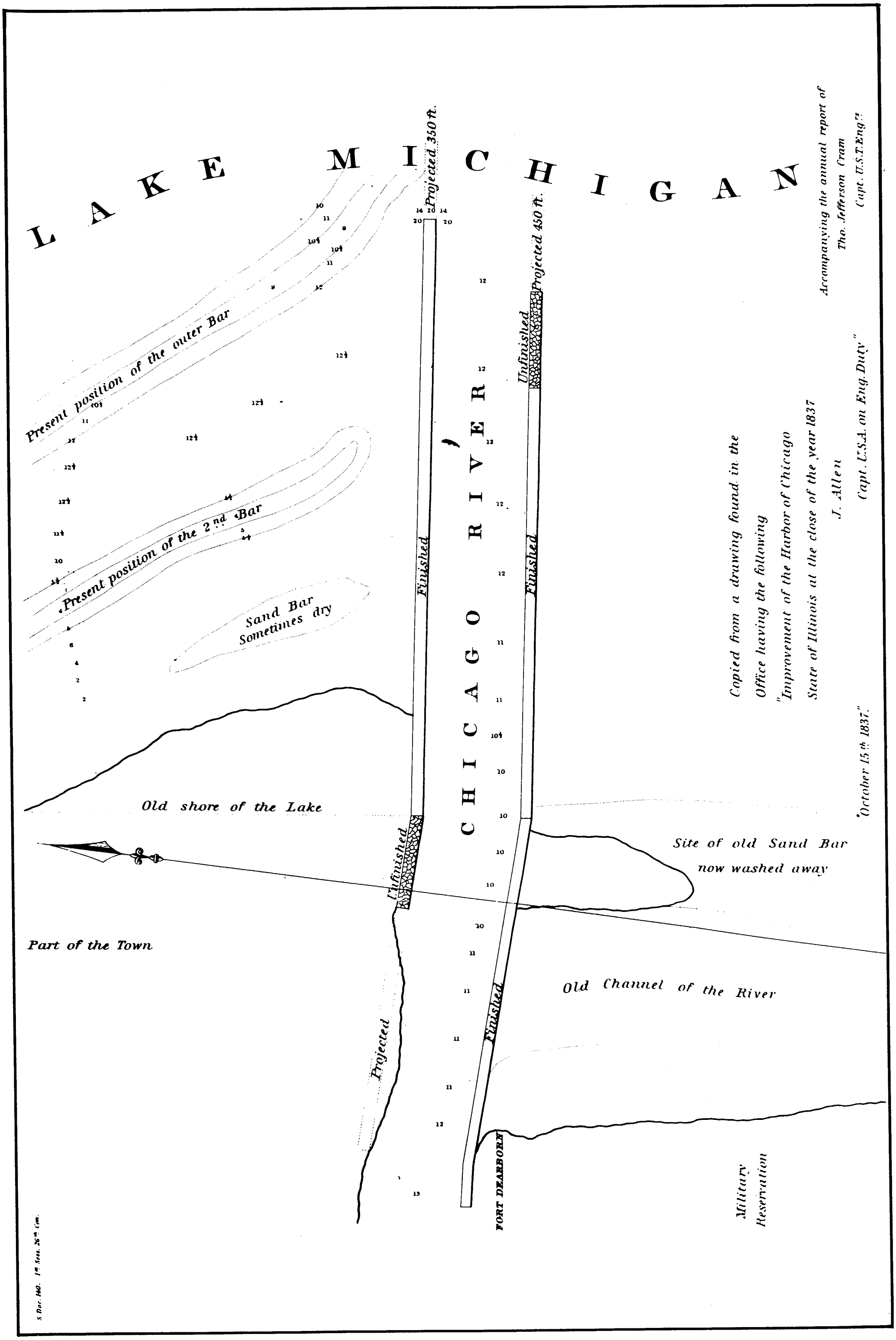

Fig. 3. Chicago harbor, 1837 (Cram, 1839), showing early effects of the harbor piers in blocking the littoral drift.

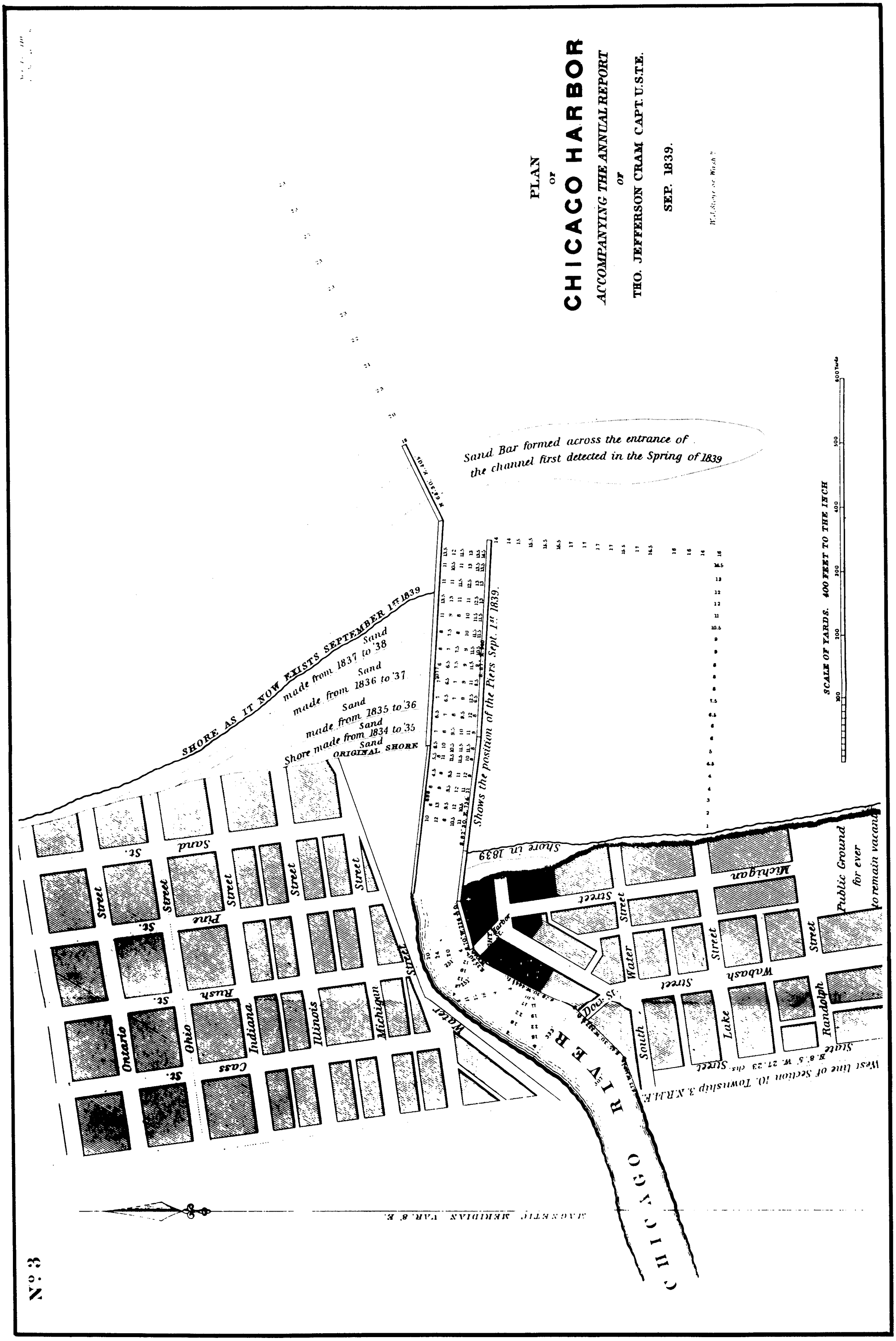

Fig. 4. Chicago harbor, 1839 (Cram, 1839).

and Black Rock from the surf of Lake Erie, or confining the sand in its place by a series of parallel piers projecting from the beach at suitable intervals, over nearly the whole of the distance included between the present pier and Buffalo Creek. The effect of this latter mode would be to cut this beach into small portions, each of which would assume such a direction that the surf caused by the prevailing westerly winds would no longer produce a progressive motion towards the north, in the particles of sand of which the beach is composed. . . ."

A year later, Williams (1839) repeated his concern that "the sands are accumulating opposite the existing Black Rock pierhead to an alarming degree . . . ," tending to fill up the harbor, and also expressed alarm over the recession of the shore to the north of the pier, where the Erie canal was becoming endangered.

Chicago Harbor, Lake Michigan

Figures 2, 3, and 4 (Cram, 1839) show the progressive changes of the mouth of the Chicago River following pier construction. The precise date of the survey for Fig. 2 is unknown, but is evidently before pier construction, the first appropriation for which was made in 1833 (Abert, 1846). Figure 3, dated October 15, 1837, exhibits a lakeward shift of both the shoreline and sand bars updrift of the piers, and a diminution of the sand bar and retreat of the shoreline downdrift of the piers. Figure 4, dated September, 1839, shows the piers to have been extended, and the updrift shoreline accumulation to have been enlarged.

Although Figs. 2-4 document updrift shoreline accretion, bar formation at the harbor mouth, and downdrift shoreline recession, the first specific comments on the latter problem appear in a letter of February 17, 1840, in which the Mayor and Common Council of Chicago petitioned the Federal government to protect the city from the "encroachments of Lake Michigan," encroachments that were caused by effects of the harbor piers (Raymond and others, 1840). The officials maintained:

"That the construction and extension of the piers forming the harbor at this place, having caused such a change in the action and effect of the waters on this shore of Lake Michigan, that immediately on the north side of said piers land is gradually forming, while on the south side thereof, it is rapidly disappearing. That, on the south side, this encroachment of the lake has progressed to an alarming extent, as will appear from the diagram hereto annexed. That, unless it be speedily arrested, a large portion of the best part of our city will soon be overwhelmed. That the cost of erecting a permanent barrier against this invasion will be great; that our city is poor, its revenues are scarcely adequate to meet its current expenses, much less to undertake a work of this magnitude and expense."

A map, Fig. 5, accompanied this letter. The line surveyed in 1821 probably corresponds to the edge of higher ground shown in Fig. 2, rather than to the shoreline of the spit; maximum retreat of the shoreline between 1821 and 1840 was at least 61 m (200 ft.). A notation on the copy of this map at the office of the Corps of Engineers in Chicago indicates that first work on the harbor piers was done in 1833, not in 1836, as indicated on the published version. It is possible that existing work was rebuilt in 1836, accounting for the discrepancy.

Further comment on the littoral processes causing bar formation at the Chicago harbor mouth was given by Col. J. D. Graham of the United States Army Topographical Engineers, who, beginning in 1854, supervised detailed surveys that included yearly positions of the accreting shoreline in the area to the north of the piers (Graham, 1857, 1858b). In a report (Graham, 1858a) he advised:

"A reference to the six maps of Chicago Harbor . . . will be sufficient to convince any

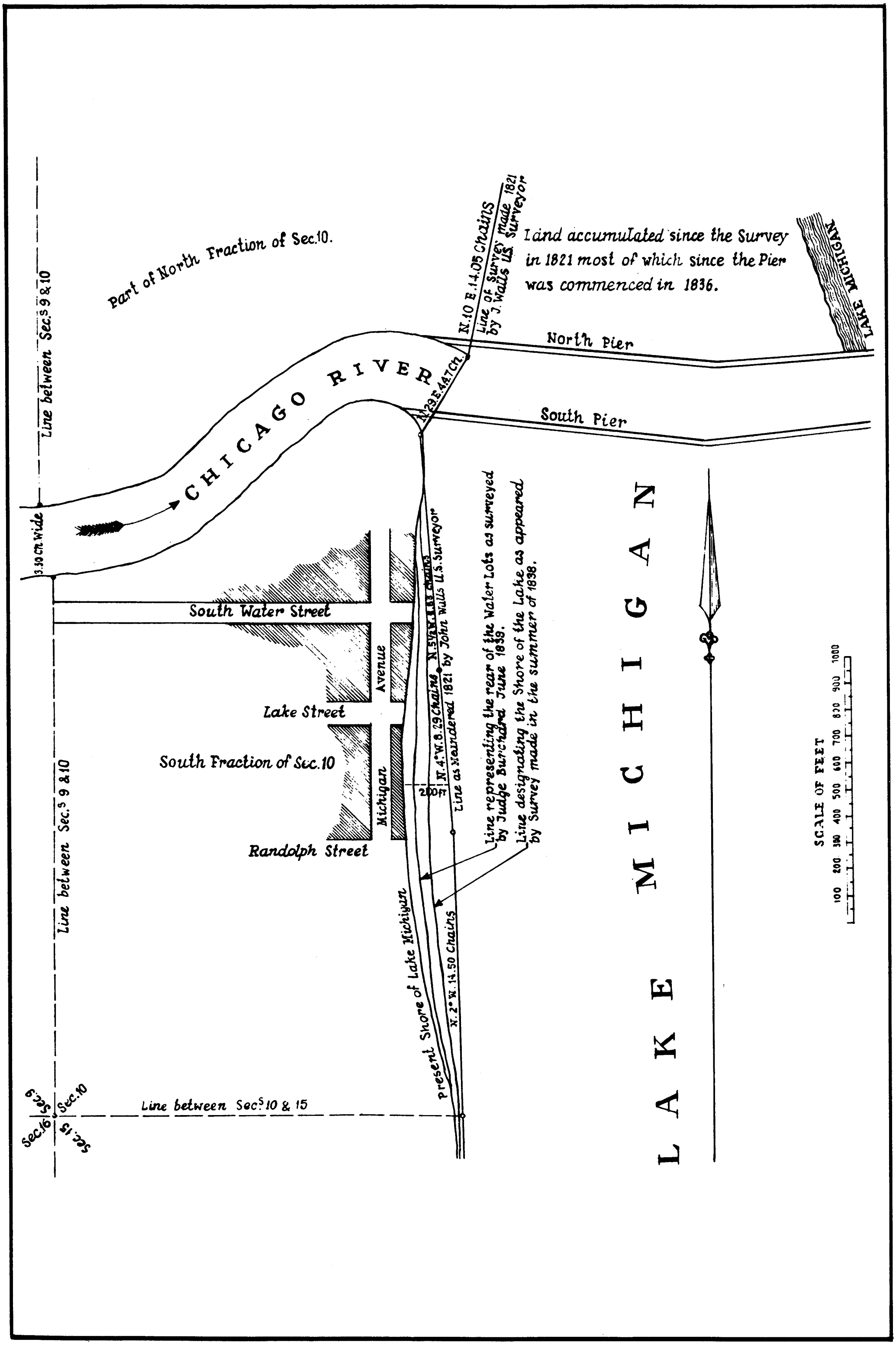

Fig. 5. Chicago harbor, 1840 (redrafted from Raymond and others, 1840). A notation on the copy of this map at the Chicago office of the United States Army Corps of Engineers indicates that first pier work, done on the south pier, was commenced in 1833, not in 1836, as here indicated. The earlier date coincides with the earliest appropriation (Albert, 1846).

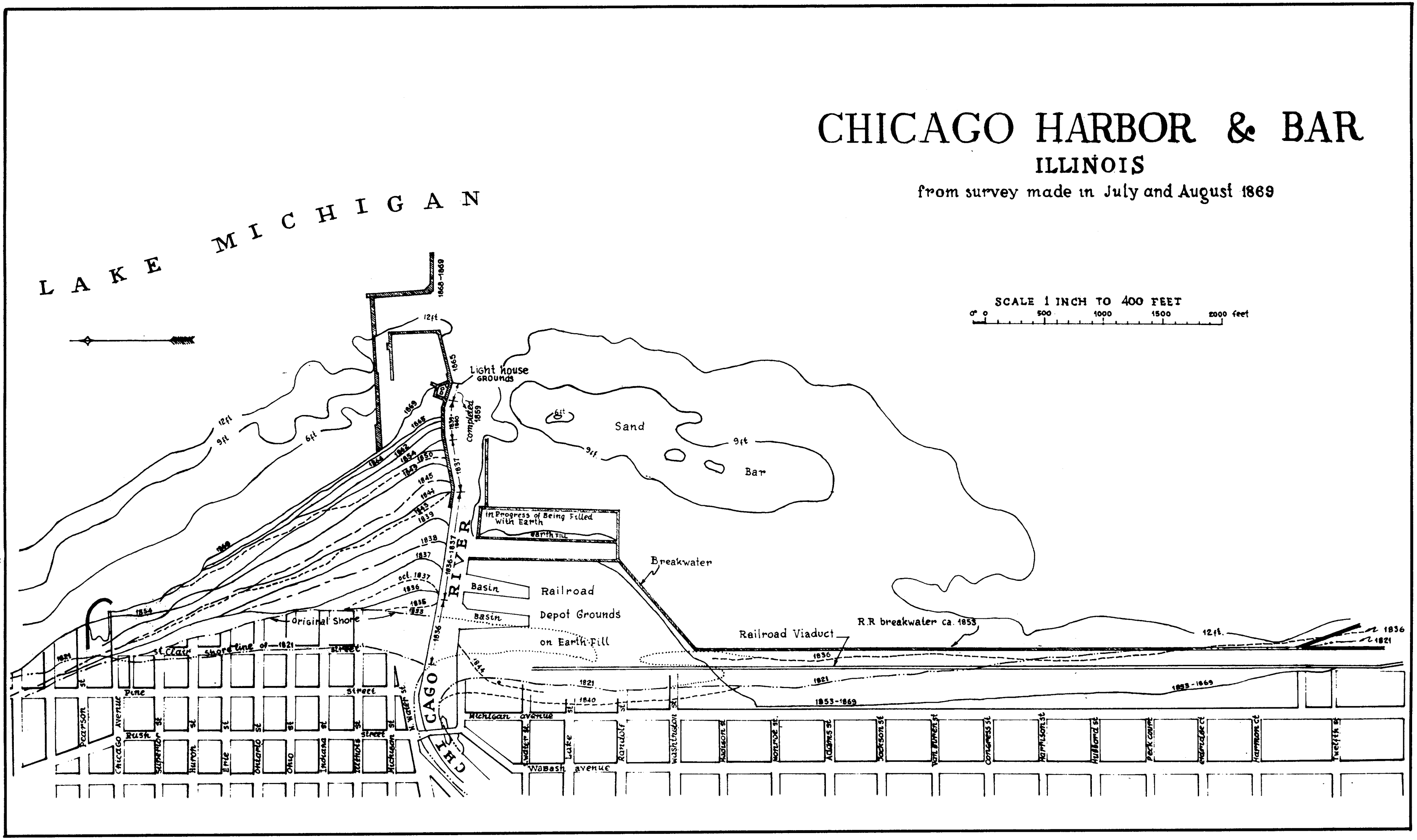

Fig. 6. Successive shorelines from 1833 to 1869 at the Chicago harbor (adapted from Wheeler, 1869). The line surveyed in 1821 probably corresponds to the edge of higher ground shown in Fig. 2.

one that however often this bar may be removed by dredging, it will re-form itself by the deposits caused by the meeting of the littoral or shore current of the lake with the obstruction of the east end of the north pier; and, moreover, that it will always assume identically the same direction, shape, and dimensions, as to width, which it had before being cut away by dredging. . . . Here, then, we have the uniform effect of a fixed hydraulic law. . . ." (p. 1103).

Shoreline changes at Chicago from 1833 to 1869 have been summarized in Fig. 6, which is based on an unpublished map by Wheeler (1869). Similar published maps are those by Graham (1857, 1858b). The outline of the spits has been manually transferred from Fig. 2, and the 1840 shoreline south of the river has been transferred from Fig. 5. The 1836 shoreline south of the river is that shown on Chicago Harbor Auxiliary Map A32 (Anon., n.d.). Dates entered parallel to the north jetty indicate the year of construction of the respective jetty segment, and were obtained from Reynolds (1865) and Chicago Harbor Auxiliary map A74 (Anon., n.d.). Wheeler's map and the Auxiliary Maps are in the collection of the Chicago District Office, U.S. Army Corps of Engineers.

To the north of the harbor jetties, yearly changes in shoreline position following jetty construction are indicated. The original shore presumably corresponds to the water's edge of the sandy area shown in Fig. 2. The shore of 1821 may represent the edge of higher ground, also indicated in Fig. 2.

The position of the paired spits has been approximated from Fig. 2. The approximate position of these spits was also shown by Alden (1902). In that work, the river mouth between the spits falls along a line between Madison and Washington Street, rather than east of Randolph Street, as indicated here. Alden also positioned the spits about 100 m (300 ft.) farther lakeward than shown here.

In Fig. 6, the position of the sand bar is after Wheeler (1869). The 12 ft. bottom contour is hardly affected by the jetty work of 1868 and 1869, suggesting that the bar's position was determined by littoral conditions that prevailed before the addition of those outermost jetty segments.

South of the harbor jetties, shorelines of 1821, 1836, 1840, 1844, and 1853-1869 are indicated. If the 1821 shoreline represents the edge of high ground, a narrow band of low riverbank probably separated it from the Chicago River, as indicated on Fig. 2. However, this low ground is not shown in Fig. 6.

It is evident that by 1853 there had been substantial retreat of almost the entire shoreline downdrift of the jetties. In that year, or in 1852, railroad track was laid south of the Chicago River along a right-of-way granted in 1852 (Hart, 1853). This grant required that the railroad construct a breakwater to protect the eroding shoreline south of the Chicago River (Brownson, 1915, p. 55). Track was laid on a trestle in shallow water, the trestle being protected by a shore-parallel breakwater. The natural shoreline, which had advanced to Michigan Avenue, was thus made part of a lagoon, and erosion in this area was halted, although it is likely that such relief was at the expense of areas downdrift of the breakwater's termination.

As at Grand River, Ohio, the zone of erosion downdrift of the harbor jetties apparently extended well beyond the downdrift limits of the surveyed area. Near the survey's limits, at Twelfth Street, the 1853-1869 shoreline is 77 m (235 ft.) landward from the 1821 shoreline, and 99 m (300 ft.) inland from the 1836 shore.

The survey of 1844 is the last record of the natural shoreline in the area between the Chicago River and Madison Street. This area became the site for landfill, on which the railroad yards were later constructed.

In 1871, Col. D. C. Houston compared the erosion problem at Chicago to that occurring at Minnesota Point, Duluth-Superior, on Lake Superior, noting that:

> "at Chicago and vicinity, where the lake drift caused by northeasterly storms is southward, that when a pier is built out into the lake and the drift arrested, the shore to the south is cut away, and works of some kind are necessary to protect it. Large amounts of money have been expended in such protections on the lake front of Chicago, south of the harbor." (Newton, 1872).

Discussion

Figures 1-6 depict situations in which harbor piers acted as littoral barriers, causing accretion along the updrift shoreline, recession along the downdrift shoreline, and deposition on the lake bottom near the piers' entrance. Unfortunately, with the possible exception of Fig. 5, these surveys do not extend far enough downdrift to enable one to determine the limits of the zone of shoreline recession. Fig. 6 suggests that this zone is very large.

The surveys demonstrate that there is a progressive reduction in the rate of advance of the shoreline updrift of newly constructed piers. Graham (1858a) noted this trend in suggesting that:

> "in proportion as the general direction of this new shore line approaches to a coincidence with the direction or thread of this littoral current, the increase is much less rapid, nearly in the inverse ratio of the elapsed time." (p. 1104).

The advance of the shoreline into the lake presumably allows a progressively larger portion of the littoral drift to migrate past the piers. It is also conceivable that the rate of the shoreline advance is slowed due to the geometry of the area of accretion, in which the accretion takes place along the hypotenuse of similar triangles, so that the available drift material must be distributed over an ever larger area. One must be cautious, however, in considering relationships between the length of the piers and the rate of change of successive shorelines shown on these maps, since the piers were built in stages. The piers shown were usually more extensive than the initial piers which first impeded the littoral drift at each site.

Lake level changes cannot account for rapid local variations of either the rate or direction of shoreline change shown on these maps. Records show that the shoreline in the areas updrift of the piers advanced at the same time that downdrift shores retreated. The map of Grand River harbor (Fig. 1), records the shoreline in 1826, 1833, 1839, 1844, 1853, and 1854, periods of both rising and falling lake levels (Williams and others, 1838; Whipple, 1859?; Henry and Lamson, 1861), yet it shows progressive accretion updrift of the harbor piers, and progressive erosion over most of the area downdrift of the piers.

Some of the surveys show little shoreline change, or even slight accretion, along the shoreline immediately downdrift of the downdrift pier (Kearney and others, 1839; and Figs. 1, 4, 5, and 6). When present, these accretions are smaller than those occurring updrift of the piers, and are succeeded downdrift by an extensive area of erosion. The piers apparently cause a local reversal of the littoral drift along a small part of the downdrift shoreline (Sato and Irie, 1970; Johnson and Eagleson, 1966), thus causing the minor accretion along the piers' downdrift flank.

These surveys provide a guage of the effects of an isolated littoral barrier on an otherwise natural shoreline. Today, various groins, seawalls, rubble mounds, and revetments line large sections of the shore, and make it difficult to evaluate the effects of a single structure. The individual or cumulative effect of the proliferation of modern structures may interfere with the normal littoral drift, and thus mask or reinforce the effect of any particular structure under consideration. In the early case histories just discussed, there are few, if any, smaller structures to complicate the interpretation.

Conclusions

In the 1830's, survey on the Great Lakes began to document the problems caused by littoral drift at shoreline harbor works. Most of these surveys were performed by the United States Army Topographical Engineers. The surveys found a recurring pattern of beach accretion along the shoreline that was updrift of the harbor piers, sediment deposition on the lake bottom near the harbor entrance, and beach erosion and shoreline retreat along the downdrift shoreline, problems that began to receive a great deal of attention half a century later (Vernon-Harcourt, 1882; Spring, 1913-1914), and which have continued to plague breakwater and pier construction to the present.

Acknowledgments

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CHEMISTRY AT THE UNIVERSITY OF WISCONSIN, 1848-1980

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Despite the enthusiasm of proponents for the new university created when Wisconsin became a state in 1848, the fledgling institution got off to an inauspicious start. It appeared improbable, during its first quarter-century, that a hundred years later it would rank among the top dozen universities in the country, with strong faculties in more than a score of academic fields, including chemistry, biochemistry, and chemical engineering.[1] When Professor John Sterling met 17 students for the first preparatory class on February 5, 1849, chemistry was not even a part of the curriculum. It was not until May, 1854, that S. P. Lathrop joined the faculty in time to teach chemistry to the two students who soon became the first graduates of the university.[2]

During the next 25 years chemistry had little prominence in the curriculum. The professor of chemistry was also professor of natural history, or of agriculture. Lathrop, the first professor, died before the end of 1854. His successor, Ezra S. Carr, did not appear in Madison until January, 1856. While some of the students found him a worthy teacher, he expended much energy on campus politics and resigned in 1867, just prior to being discharged. His professorship of chemistry and natural history went to a recent graduate of Lawrence University and the Chicago Medical College, John Da-

S. Pearl Lathrop (1816-1854)
Prof. of Chemistry and Natural History, 1854

Ezra S. Carr (1819-1894)
Prof. of Chemistry and Natural History, 1856-1868

vies, the third occupant of the chemistry chair to come out of the medical profession.[3]

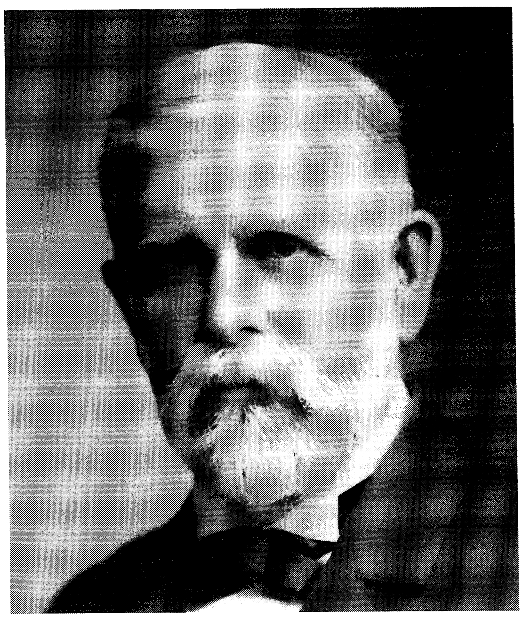
The coming of Davies was coincident with the beginning of better days for the university. It had barely survived its first decade because of financial problems. The second decade was hardly better since the Civil War decimated enrollments, causing further problems which were only partially resolved by admission of women to the normal department, set up for the training of schoolteachers.

The post-war years, however, were good ones for higher education in America. Passage of the Morrill Act provided land grants by which the federal government encouraged the states to establish colleges of agriculture and mechanic arts. Wisconsin did not follow the paths of Ohio, Indiana, Michigan, Iowa, California, and other states who set aside their land grants for state colleges of agriculture and engineering. Instead, the Wisconsin legislature, in spite of considerable opposition, assigned its land grant to the existing university. While this may have delayed the growth of a viable agricultural college, it injected strength into the existing university without preventing the ultimate development of a leading agricultural program.[4]

In line with the mandate to provide instruction in agriculture, the university brought W. W. Daniells to the campus in early 1868 as the first professor of agriculture. A graduate of the Michigan Agricultural College (present Michigan State U), he had just spent a year in Harvard's Lawrence Scientific School studying chemistry with O. Wolcott Gibbs. Since Wisconsin farm boys stayed away from the new agricultural department in droves, Daniells' principal activity was teaching chemistry and managing the college farm. During his first year in Madison his title became Professor of Agriculture and Analytical Chemistry. Even in his first term he taught chemical analysis to a single student, using a carpenter's bench in the basement of University Hall (Bascom) as a work table.[5]

During the next decade Davies' work focused more and more on physics and astronomy while Daniells took over great responsibility for chemistry. The agricultural program was a disappointment, whether because of or in spite of Daniells is unclear. At any rate, 'book larnin' was unpopular with Wisconsin farmers and their sons stayed home or enrolled in other courses. Meanwhile Daniells became disenchanted with management of the university farm, which was expected to show a profit. In 1880 when the chemistry program was given departmental status with Daniells as its first chairman and sole professor, he was happy to turn the agricultural program over to William Henry, the new botany professor.

The university had reached the point where professors were expected to be specialists in a single discipline. Davies had already abandoned chemistry and was now the chairman



W. W. Daniells (1840-1911)
Prof. of Agriculture and Chemistry, 1868-1880
Prof. of Chemistry and Chairman, 1880-1907

of the physics department. In addition, Roland Irving was professor of geology, Edward Holden of astronomy, William Henry of botany (and agriculture), E. A. Birge of zoology, and Sterling of mathematics.

The eighties was a decade of rapid growth in enrollment and faculty size. It was during this decade that Thomas Chrowder Chamberlin took over the presidency from John Bascom. Since 1874 Bascom had directed the growth of the university and overseen the separation of clustered disciplines into departments and the expansion of these departments. He had engaged in a renewed building program which included a Science Hall and an Observatory outfitted with an excellent 15-inch refractor. An engineering program had been stabilized, a pharmacy course initiated under the guidance of the talented plant chemist, Frederick Power, and agriculture given an investigatory mission even though there were no students. Scholarly investigation had begun to emerge, most notably in the work of historian William F. Allen and geologist Roland Irving.[6]

Chamberlin continued the momentum generated under Bascom. A leading American geologist who had been prominently associated with the Wisconsin Geological Survey, Chamberlin recognized those moves which were essential to change the parochial image which had characterized the university in the past. Henry was encouraged to build the agriculture department into an activity having interest to Wisconsin's farmers. A short course was opened during the winter months when farm work was minimal. If farm boys would not enter the university for a complete education, they might at least spend the winter in Madison gaining knowledge of new ideas in farm practice. The experiment was a success. A few years later, after S. M. Babcock perfected the famous test for butterfat in milk, a short course for cheesemakers was created.[7]

Perhaps most important in the Chamberlin presidency was the evolution of a serious graduate program under the direction of astronomer George Comstock. Masters degrees had been granted from 1856 but they, like masters degrees granted by many American colleges in the nineteenth century, were more nearly representative of good behavior for a few years following receipt of the baccalaureate degree, than of a serious intellectual input. In 1874, during Bascom's presidency, the first M.S. degrees in course, were granted. The graduate program escalated during the Chamberlin period with the first Ph.D. being granted in 1892 for studies in geology. The recipient was Richard Van Hise, who stayed as Professor of Geology and in 1903 became the University's eighth president. Van Hise, following receipt of his B.S. in 1879, had served Daniells as an assistant in chemistry.[8]

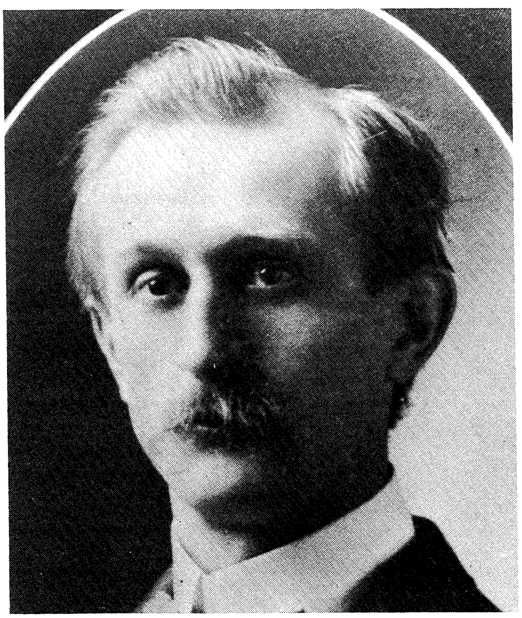
Chamberlin left Madison in 1892 to become a professor of geology at Chicago where Rockefeller money had just created a vigorous university with a strong faculty attracted from less affluent institutions. The new president, Charles Kendall Adams, was a man of repute in educational circles who, despite poor health, continued the momentum established under Bascom and Chamberlin.

The chemistry department continued the growth that had started under Bascom and Chamberlin. Daniells, while not a brilliant chemist or teacher, was nevertheless a conscientious, hardworking professor who was not afraid to hire faculty members whose qualifications exceeded his own. Homer Hillyer came in 1885, fresh from a Ph.D. under Ira Remsen at Johns Hopkins. He took over and expanded the work in organic chemistry. Although he never became a leader in this field, he developed a modest research program and served as advisor for those chemistry majors doing work toward senior and masters' theses.[9] Among these students was a second generation German-American from Two Rivers, Louis Kahlenberg.

In 1892, following completion of his B.S., Kahlenberg was made a fellow in chemistry while he completed work for his master's degree under Hillyer. At that point, he became an instructor in the department.

During this period Kahlenberg was hearing about the work in the new area of physical chemistry which was developing in Germany. He resigned his instructorship in 1894 and embarked for Leipzig to study under Wilhelm Ostwald, the recognized master of the new discipline. His Ph.D. was granted, *summa cum laude,* in 1895. Kahlenberg headed back to America, enthusiastic about the new physical chemistry being created by Arrhenius, van't Hoff, and Ostwald.

Upon arrival in Madison Kahlenberg learned that the chemistry department had hired Arthur P. Saunders, a recent Ph.D. from Johns Hopkins. There was no room for another man on the staff. Thereupon, Kahlenberg called upon Edward Kremers, director of the pharmacy program, who hired him as instructor of pharmaceutical technique and physical chemistry. Thus, physical chemistry had its origins at Wisconsin in the school of pharmacy, not in the department of chemistry. The absurdity of the situation was rectified a year later when Saunders resigned to take a *Wanderjahre* in Germany and Kahlenberg was appointed instructor in physical chemistry.[10]



Louis Kahlenberg (1870-1941)
U.W. Chemistry Faculty, 1896-1940
Chairman, 1907-1919

Immediately after returning to Wisconsin Kahlenberg initiated a research program in chemistry of solutions. He was soon joined by a few undergraduates and graduate students. The first Ph.D. in chemistry was conferred upon Azariah T. Lincoln in 1899 for research on solutions done under Kahlenberg's direction, the second, in 1901, on Kahlenberg's boyhood friend, Herman Schlundt. Both of these men went on the respected careers as academic chemists, Lincoln as chairman of the chemistry department for many years at Carleton College, Schlundt holding a similar position at the University of Missouri.[11]

From the early years of the twentieth century, the chemistry department began to acquire visibility, not only in the university but on the national chemical scene. This was coincident with a vigorous period of development under President Van Hise (1903-1918) when the university acquired a unique image in the educational world. Van Hise had entered the presidency as a respected leader in stratigraphic geology. He knew, from his involvement in the development of mineral deposits, the potential for successful interplay between academicians and those in practical endeavors. During his presidency that potential was exploited, particularly in the interface between education and government, in the form of what became known as The Wisconsin Idea. Van Hise believed that "The boundaries of the University are the boundaries of the State."[12]

The circumstances were propitious since Robert M. LaFollette had been elected Governor in 1900. He and the university developed a symbiotic relationship whereby university professors were used as advisors in developing those governmental innovations which came to be known as the Progressive Movement. At the same time, the university found at the Capitol end of State Street a more sympathetic attitude than during its first half century.

During the period between 1900 and the end of World War I the chemistry department grew rapidly, not only in enrollment in courses and size of faculty, but in national recognition. While only a handful of graduate students were enrolled in 1900, there were 42 in 1920. Some of this increase is attributable to the post-war enthusiasm for chemistry in all graduate schools, but even before the war there had been a steady growth in the number of students who selected Wisconsin for graduate study in chemistry.[13]

Victor Lenher was added to the chemistry staff in 1900, very largely to strengthen the program in analytical and inorganic chemistry. He had taken a Ph.D. with Edgar Fahs Smith at Pennsylvania in 1898. Lenher initiated a research program in the chemistry of the lesser-known elements and, at the time of his death in 1927, probably from toxic metal poisoning, he was widely recognized for his work on selenium and tellurium.[14]

Hillyer, who was pushed out of the department in 1905, joined the National Chemical Co.; he was replaced by a promising young organic chemist, Frederick Koelker, who had just completed his Ph.D. with Emil Fischer in Berlin. Koelker's career was short-lived; he entered a mental institution in 1909 and died two years later. Responsibilities for organic chemistry were taken over by Richard Fischer, a member of the pharmacy faculty, when Koelker became ill. Fischer had, following degrees in pharmacy and chemistry at Michigan, been an instructor in pharmacy at Wisconsin. In 1898 he started graduate work in Germany, spending a term with Emil Fischer in Berlin, then migrating to Marburg where he completed the Ph.D. under Ernst Schmidt, authority on alkaloids, in 1900. He immediately returned to Wisconsin as assistant professor of pharmacy and in 1903, took on the added duties of State Chemist, responsible for enforcement of the dairy and food laws. Soon after taking over Koelker's courses he was made a permanent member of the chemistry department.[15]

When Daniells approached retirement in 1907, Kahlenberg was the obvious choice for chairman. His teaching style had given him an awed, but admiring, following. His research had gained him international, albeit contentious, attention. Although he had returned to America with great enthusiasm for the new theory of solutions, as had other American boys who studied in Ostwald's laboratory, Kahlenberg's research program at Wisconsin soon recognized shortcomings in the official dogma of ionization theory. Studies on nonaqueous solvents, as well as work on concentrated solutions, convinced Kahlenberg that supporters of the theories of Arrhenius and van't Hoff were extending the power of those theories beyond the dictates of good sense. Never one to retire from an area of contention, Kahlenberg opened a lifelong attack on the theory of ionization. This earned him the enmity of most physical chemists but there is evidence that he gloried in their disapproval. At any rate, it did not deter his superiors from appointing him to the departmental chairmanship. He entered into the work with enthusiasm. Staff expansion was quickly made and the department created the Chemistry Course.[16]

James H. Walton, with a doctorate under Georg Bredig in Heidelberg, was brought into the faculty in 1907, in part to spread the responsibility for the growing freshman chemistry instruction, in part to introduce a new dimension into the research program. At about the same time Francis Krauskopf, still a graduate student at Cornell, was brought in to help with the freshman program. Upon the strong recommendation of Cornell's Wilder D. Bancroft, under whom Krauskopf was studying, he was invited to take an instructorship at Wisconsin. There he completed his Ph.D. under Kahlenberg and became a permanent member of the faculty. During their first decade at Wisconsin he and Walton played a very secondary role to Kahlenberg in the freshman chemistry program but after the post-war reorganization they took over full responsibility for all general chemistry students except the engineers. Despite a marked difference in personality, they complemented each other and made an effective team. Walton was an austere New Englander of forbidding physical physique who disliked detail, but had a compulsive drive to make policy; Krauskopf was a gentle soul with enormous patience for detail, but an intolerance for fools and the irresponsible. Both were talented teachers who, for four decades, orchestrated the evergrowing service course with remarkable effectiveness. Each pursued a modest research program, but their real forte was in the classroom. They died within six months of one another, a year short of retirement, in 1947.[17]

Except for a few instructors whose association with the department was transient, the pre-war faculty was completed with the return of J. Howard Mathews and the advancement of H. A. Schuette. Both had been undergraduates in the department. After Mathews finished his M.S. under Kahlenberg he continued his graduate studies under T. W. Richards at Harvard. Richards had an international reputation as a result of his accurate work on atomic weights and, in 1914, became the first American Nobel laureate in chemistry. In 1908, upon completion of his Ph.D., Mathews joined the Wisconsin faculty. Schuette, a bit younger, completed his B.S. in 1910 and stayed on for graduate work with Professor Fischer. In 1914, two years before completing his doctorate, he took over Fischer's courses in food analysis and developed that area during the remainder of his career.

The pre-war faculty represented a diversity of fields and presented a program of broad appeal. Graduate students were attracted from a wide geographic base and by 1910 several Ph.D.'s were being awarded annually. Still, all was not harmonious. Kahlenberg monopolized the graduate students and his autocratic behavior as chairman led to factionalism in the department. His effectiveness was further jeopardized by the manner in which he was becoming isolated from the mainstream of American chemistry because of his opposition to ions. Nevertheless he had the firm support of President Van Hise; the chemistry department was looked upon favorably by the university community.[18]

During the war years the strains within the department were exacerbated. Wisconsin, with a large German ethnic population, was suspect with regard to loyalty to the American cause. Senator La Follette, because of his questioning of President Wilson's policies, which he considered likely to involve the United States in war, was receiving severe criticism around the country and in his own state.[19] Extreme polarization took place, even in the university community. Kahlenberg, never one to hide his views, spoke out in opposition to the direction the country appeared to be taking. Although there is no sound evidence to question his loyalty, Kahlenberg was vigorously denounced. The department's other professors with German doctorates showed opposing reactions: mild-mannered Richard Fischer made no statements, but, since he failed to sign the faculty round robin denouncing Senator La Follette, he was suspect; James Walton quickly offered his expertise to the government for research on chemical warfare and his loyalty was never questioned.[20]

Once the United States became a belligerent, the university's program went on a wartime basis. Many male students enlisted or were drafted. Military training programs appeared on campus. As faculty members left to become involved in wartime projects, the teaching loads of those remaining behind became heavier. The chemistry department lost the services of Lenher, Walton, Mathews, and instructor Carleton. There was suspicion about the Americanism of those remaining behind to teach the classes: Kahlenberg, Fischer, Krauskopf, and Schuette.

Even before the war ended, a Palace Revolt was generating. President Van Hise was sent notice by Harold Bradley, professor of physiological chemistry in the medical school and a chemical warfare service volunteer, that the Wisconsin chemistry faculty in service would probably not return if Kahlenberg remained chairman. Van Hise never received the letter since he died the day it was written; Dean Birge, as Acting President, took action. Birge had always been cool toward Kahlenberg and, as early as 1900, had brought Lenher into the department as a counterbalance. Van Hise, who respected Kahlenberg as a chemist, had also begun to have reservations in his last years. At any rate, Birge sought and found support from other campus scientists; Kahlenberg received the axe. He was permitted to retain his professorship, but lost his chairmanship and the physical chemistry course he prized. He remained a popular teacher of freshman engineers for another twenty years, but found himself without influence in the department and remained outside the mainstream of American chemistry as a consequence of his opposition to ions.[21]

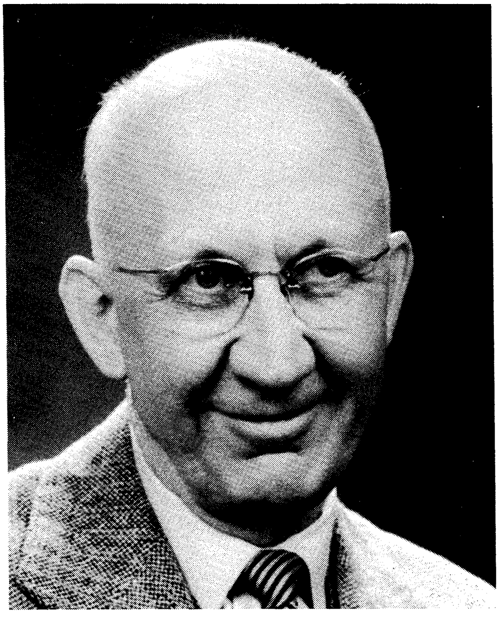
As the university prepared itself for vigorous post-war activity the problem of the chairmanship of the chemistry department was resolved, although not without considerable internal strain even if that strain was not obvious to the general public. Of the rebel faction, Lenher was the one member with a national reputation and he coveted the chairmanship. However, his popularity in the department, and even in the camp of the rebels, was insufficient to bring about his selection. The strategy of the dissident group, therefore, became one of attacking Fischer's failure to have developed an organic research program of broad visibility. Birge was informed that organic chemistry would be particularly attractive in post-war America, where the country would wish to attain international leadership in its chemical industry. Therefore it would be desirable to bring in a widely recognized organic chemist who might bring luster to that division of chemistry and, at the same time, take over the chairmanship. Marston T. Bogert of Columbia was suggested.

Discreet inquiries were made in the East about Bogert. The reports were not favorable and the suggestion was not pursued. It became obvious that a chairman must be selected, at least for the present, from the inner circle. The choice fell on J. Howard Mathews, the youngest of the returning rebels, who took office in summer, 1919. The

J. Howard Mathews (1881-1970)
U.W. Chemistry Faculty, 1908-1952
Chairman, 1919-1952

choice proved to be a fortunate one, and Mathews retained the chairmanship up to the time of his retirement 33 years later.

Mathews quickly demonstrated a flair for administration. Deeply devoted to the success of the chemistry department, he worked untiringly for its welfare. The momentum the department had gained during the Kahlenberg chairmanship was given an additional thrust early in the Mathews period. Of particular significance was the fact that Mathews, in contrast to Kahlenberg who sought greatest visibility for himself, was not afraid to surround himself with chemists who were better scientists than himself. Mathews was an excellent judge of men and repeatedly succeeded in bringing promising young men into the faculty. He was prone to provide all possible support for development of their programs as soon as he was convinced they understood their objectives. At the same time, he never hesitated to terminate a man whose performance failed to measure up to expectations. He was not loved by his faculty, but he was deeply respected.[22]



Homer Adkins (1892-1949)
U.W. Chemistry Faculty, 1919-1949

During Mathews' very first year, the organic program was stimulated by the hiring of Homer Adkins, a recent Ph.D. from Ohio State. Adkins proved to be a hard-driving investigator who quickly became a natural leader in the department. His research soon attracted national attention and, well before his untimely death in 1949, he was ranked alongside Roger Adams, Frank Whitmore, and James B. Conant as an American leader in organic chemistry.[23]

In 1923, S. M. McElvain completed his Ph.D. under Roger Adams at Illinois and joined the organic group at Wisconsin. McElvain also proved to be a blue ribbon selection whose research quickly gained visibility.[24] Graduate students of high quality were soon coming in large numbers to study under Adkins or McElvain. Both were challenging teachers of advanced material and both were effective guides of graduate students.

Richard Fischer, although overshadowed by his younger colleagues, still held an important role in the department where he and one of his last graduate students, Michael Klein, carried the major responsibility for the undergraduate organic courses. Enrollment in these courses increased rapidly during the twenties, partly because of the increasing numbers of chemistry majors and partially because of the importance of elementary organic chemistry as a service course for students headed for medicine, pharmacy, engineering, and agriculture. Had Fischer and Klein not had a deep interest in elementary students, coupled with only a casual interest in research, the research programs of Adkins and McElvain might not have developed as smoothly.[25]

Mathews also took initiative in improving the physical chemistry program. Farrington Daniels, a 1914 Ph.D. with T. W. Richards, left the U.S. Nitrogen Fixation Laboratory in 1920 to join the department at Wisconsin. He quickly made his mark on both instructional and research programs. Daniels' suggestions for improvements in the textbook used in the physical chemistry course led its author, Frederick Getman of Mount Holyoke College, to invite him to become a coauthor. Daniels soon became a major author and the book became the standard textbook in American colleges for three decades. He also authored a text on mathematical preparation for physical chemistry and led a team of Wisconsin physical chemists in writing a laboratory manual which became widely used throughout the country.

Daniels continued research begun at the Nitrogen Fixation Laboratory and became a leading authority on the properties and reactions of oxides of nitrogen. These studies ultimately diverged, as Daniels became deeply interested in chemical kinetics on one hand and large scale nitrogen fixation on the other. Around 1940 he became involved in the direct combination of nitrogen and oxygen in a gas-fired, regenerative furnace. Although the process was developed through the pilot plant stage, it never quite became competitive with the Haber process. Daniels also contributed extensively in the field of photochemistry during these early years.[26]

Chairman Mathews was always active in developing promising new areas of chemistry. In 1923 he brought The Svedberg from Uppsala in order to focus attention on the field of colloid chemistry. Svedberg, with the assistance of a group of graduate students, built and tested a new device, an optical centrifuge, which served as a precursor of the ultracentrifuge designed and built at the University of Uppsala upon his return.

The Svedberg visit produced several developments at Wisconsin. Most immediate was Mathews' organization of a National Colloid Symposium, which brought together most American chemists interested in colloid chemistry at a summertime conference in Madison. The Colloid Symposium became an annual affair, with every tenth meeting returning to Madison. Mathews' dream of a National Colloid Institute to be housed on the campus in Madison failed to receive funding with the onset of the Depression and had to be abandoned.

He was more successful in creating an ongoing program in colloid chemistry within the department, however. After John W. Williams completed his Ph.D. under Daniels in 1925, he was brought into the faculty and encouraged to pursue studies in colloid chemistry.[27] In the late thirties, the program received a significant stimulus when a Svedberg ultracentrifuge was given to the department. This became the focal point for studies of sedimentation characteristics of complex systems such as proteins.

Instrumentation also received attention in the analytical division. Mathews, like his mentor T. W. Richards, had a compulsive interest in instruments. He was a talented photographer and was at his best in the classroom when he was describing instruments for studying chemical phenomena. He recognized earlier than most of his peers the power which instruments might have for the unravelling of chemical problems. When an addition to the Chemistry Building was completed in 1929, it contained a sizeable instrumental laboratory which soon contained the most recent spectrographs, colorimeters, pH meters, and polarographs. The laboratory was placed under the direction of Villiers W. Meloche, who was retained on the faculty after completion of his Ph.D. under Lenher in 1925.[28] The Instrumental Laboratory served not only as a teaching laboratory for instrumental analysis, but as a service laboratory for research within the department and in laboratories in other parts of the university. The chemistry department was well known around the campus for its willingness to provide assistance to others involved in chemical problems.

Although Mathews was not looked upon as a great teacher, he was nevertheless supportive of good teaching in the department and frequently fought with deans and presidents for greater support in getting instructional work done. His success in this direction was no doubt aided by the fact that his superiors in the administration knew that he was tight-fisted with money. He was trustworthy in budget planning, and consequently, administrators were inclined to meet his demands if the money could be found. As a result, he was successful in obtaining appropriations for substantial additions to the Chemistry Building in 1928 and again in 1938. He was also reasonably successful in adding teaching staff when enrollment in service courses became tight. This was true, not only in providing adequate funding for teaching assistants from the corps of graduate students, but in adding instructors, some of whom were later moved up to tenured professorial status. C. Harvey Sorum was retained, after completing his Ph.D. with Krauskopf in 1927, to become a part of the Walton-Krauskopf team.[29] Later the chemistry majors and chemical engineers were split from the general survey courses and Sorum developed a special course for these students. His problem book, his manual for semimicro qualitative analysis, and his textbook became widely used in American institutions. M. L. Holt was similarly retained, upon completion of his doctorate with Kahlenberg in 1930, to work with his mentor in the course for freshman engineers. Holt took over that course upon Kahlenberg's retirement in 1940.[30]

By the end of the twenties the department had expanded and reached a state of apparent stability. The void left in analytical chemistry by Lenher's death in 1927 was widened by the sudden death of George Kemmerer, a Pennsylvania Ph.D. who moved from Carroll College to Wisconsin in 1920.[31] Professor Meloche, who stepped in valiantly to keep the analytical chemistry program going, was finally joined in 1929 by Norris F. Hall, who became the third Richards Ph.D. on the professorial staff.[32]

In summarizing the personnel of the department at the end of the twenties decade, mention must be made of Professor Schuette who had been responsible for organic analysis and food chemistry since 1914. His role in the department always remained somewhat ambiguous, since quantitative organic analysis was hardly accepted in the mainstream of the organic program, and was not looked upon with enthusiasm by the analytical chemists, who were all concerned with the analysis of inorganic substances. Schuette's field, therefore, developed very largely as a separate program which, nevertheless, attracted a strong following among students.[33]

With the onset of the economic depression in the last days of 1929, the chemistry department, along with the rest of the university, entered into a long period of financial stringency. There were no further additions to the faculty after Hall and Holt were brought in until 1937, when John Willard, a Daniels Ph.D. in 1935, was added to the general chemistry group.[34] The enrollment decreases in the early thirties were soon slowed, partially as a consequence of government aid to students. The science departments at Wisconsin were more fortunate than their counterparts elsewhere, because of research grants originating from the Wisconsin Alumni Research Foundation (WARF). Professor Harry Steenbock of the agricultural chemistry department had discovered in 1924 that exposure of food to ultraviolet light led to fortification of the food with vitamin D. Patents on the process were assigned to the newly formed Foundation for management. Income from the arrangement began to be funneled into the Graduate School at the time of the Depression. This enabled the university to retain faculty members who might otherwise have been released. It also enabled science departments to provide fellowships for graduate students and even for students who were unemployed after completing their degrees.[35] Among those benefitted by fellowship aid was Stanford Moore, Ph.D. 1938 under Adkins and agricultural chemist, K. P. Link; Moore's later research at Rockefeller University led to the 1972 Nobel Prize in Chemistry.[36] Link's research on naturally-occurring anticoagulants later led to patents whose income added substantially to the WARF fund.[37]

By the end of the thirties the economy had not fully recovered, but circumstances had improved to the point that the department might undertake projects which had been delayed. The addition to the building in 1939 has been mentioned, as has the hiring of Willard. Joseph Hirschfelder was moved up to an instructorship in 1940. He had taken a double major for the Ph.D. at Princeton in 1936, working in chemistry under Henry Eyring and in physics under Eugene Wigner. After another year at Princeton in the Institute for Advanced Study he came to Wisconsin as a research fellow supported by WARF until 1939 when he was given a faculty appointment. Hirschfelder took leave soon after involvement of the U.S. in World War II and returned after the war as a full professor. At that time he established a Theoretical Chemistry Institute, enabling him to build a unique staff for the study of theoretical problems related to flame propagation, equations of state, and molecular quantum mechanics.[38]

The year 1940 also saw the coming of two promising young organic chemists, A. L. Wilds and William S. Johnson. Wilds had just had a major role in the successful synthesis of equilenin in Werner Bachmann's laboratory at Michigan.[39] Johnson had also worked on steroid chemistry as a graduate student under Louis Fieser at Harvard. Both quickly attracted an enthusiastic group of graduate students as they continued their research on steroids. Johnson left Wisconsin in 1960 to become chairman of the chemistry department at Stanford.[40]

The last faculty additions in the early forties occurred in 1942, when Paul Bender, Aaron Ihde and Edwin Larsen joined the faculty. Bender, who joined the physical group, had just completed his doctorate at Yale under G. Ackerlov. He was a talented instrumentalist and quickly became involved in the expansion of the instrumental holdings and shop facilities. For many years he was chairman of the shop committee.[41] For Larsen and Ihde it was a return to alma mater in order to work with the freshman chemistry program, which had just lost three instructors. Ihde had completed his doctorate in 1941, working in food chemistry under Schuette. Larsen had taken his B.S. at Wisconsin, then gone to Ohio State for a 1942 doctorate under W. C. Fernelius. He became associated with Holt's course for the freshmen engineers and instituted a research program which dealt with the chemistry of the less familiar elements.[42] Ihde became deeply involved with the Walton-Krauskopf team. After the wartime urgencies abated he turned part of his attention to science in the new program of Integrated Liberal Studies and also began the development of his work in the history of chemistry.[43]

The wartime years saw a badly strained department. The program which became known as the Manhattan Project drew off Daniels, Willard and Larsen. Hirschfielder joined the National Defense Research Committee as a consultant on interior ballistics of guns and rockets and as group leader of the geophysics laboratory. He later served with the Naval Ordnance Test Station, and in 1946 was assigned chief phenomenologist for the Bikini atom bomb test. McElvain served as consultant to the NDRC and Adkins was deeply involved in mission oriented research for the Office of Scientific Research and Development which led to 8 restricted reports dealing with chemical warfare agents and defense against them. In addition, his laboratory at Wisconsin investigated the synthesis of antimalarial agents. Wilds also served as an investigator for the NDRC and Williams became deeply involved in government research on blood plasma proteins and blood plasma extenders.

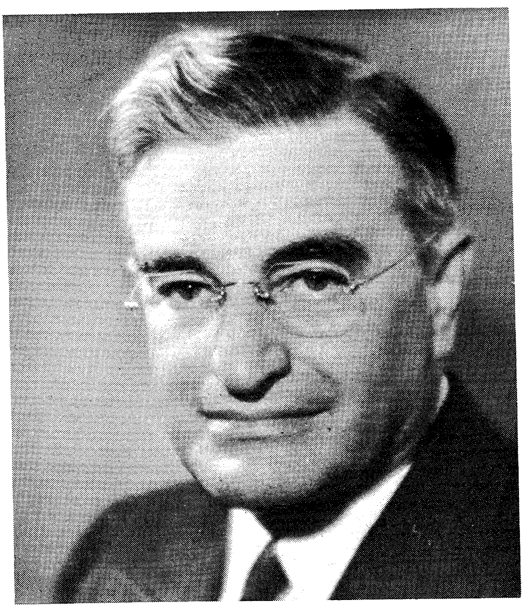
Teaching responsibilities remained heavy during the war years, despite student enlistments and losses through the draft. The military based a number of special training programs on the campus and instruction of such courses was frequently out of step with the academic calendar, thereby necessitating complex teaching arrangements for the faculty. Once the war ended, enrollment mushroomed as discharged military personnel returned to civilian life. The GI Bill of Rights enabled many such persons to embark upon a college education and the faculty at Madison was willing, as usual, to take aboard all qualified comers (as well as some not so qualified).

Freshman chemistry courses, which were required in many areas outside chemistry itself (agriculture, engineering, medicine pharmacy, home economics, nursing, medical technology, and even physical education), presented a critical problem, even during the war years. A major innovation was introduced in 1944 when Odell Taliaferro was appointed a full-time lecture assistant, largely through the leadership of Professor Walton who had, for more than two decades, taken great pride in the success of the large introductory lectures. From the beginning of the century, and even before, lecture demonstrations had had an important role in clarification of the subject. At first, professors like Carr and Daniells had prepared their own demonstrations. Later, when graduate students appeared, individual teaching assistants were assigned to particular lecturers to prepare demonstration materials. The system never worked satisfactorily since, unless professors worked closely with the lecture assistant, apparatus was missing when needed, materials were not checked properly before class, and demonstrations frequently failed. The appointment of Taliaferro, a former chemistry major in the department, proved a striking factor in maintaining the quality of the instructional program in the decades which followed.[44]

The freshman chemistry problem was exacerbated in 1947 by the deaths of Walton and Krauskopf, but helped by the recent return of Willard and Larsen. A heavy hiring program brought in seven recent Ph.D's as instructors between 1946 and 1950. These men were supplemented by several temporary instructors drawn from available personnel, mostly advanced graduate students. Laboratory sections were scheduled on Saturday mornings and in the evenings. Since teaching assistants from graduate student ranks were in short supply, their numbers were supplemented with seniors from the Chemistry Course. Somehow, the freshman courses were taught. Professors Willard and Larsen even managed to resume and expand their research programs in radiochemistry and lesser-known elements. Edward King and John Margrave, who arrived as instructors during the expansion period, contributed impressively both in the classroom and in developing a research program. They were quickly promoted to tenure.[45]

Work in more advanced levels also suffered from growing pains, with similar expansions being only slightly delayed. The analytical division added Walter Blaedel,[46] a recent Ph.D. under Leighton at Stanford, in 1947, and Irving Shain,[47] Ph.D. 1952 at University of Washington under Crittenden, in 1952. Organic added Harlan Goering, a student of S. J. Crystol at Colorado and Eugene van Tamelen, who had just taken his doctorate at Harvard under Gilbert Storck (Wisconsin '45 under McElvain). Both came in 1950 and immediately contributed significantly to the organic program, which had recently suffered the untimely death of Adkins. Despite that loss, the organic division remained an attractive one.[48]

The physical division was also showing a concern for the future. John Ferry came in 1945 as a young chemist with an established reputation in high polymers. Following receipt of a Stanford Ph.D. under George Parks, he had spent nine years at Harvard as instructor, member of the Harvard Society of Fellows, and associate chemist at Woods Hole. In 1959 he became the department's fifth chairman.[49] Robert Alberty was made an instructor in 1947, upon completing his doctorate under Professor Williams. Another Wisconsin Ph.D., Charles Curtiss, was added to the faculty the next year. He had studied with Hirschfelder and held a joint appointment with the Theoretical Chemistry Institute. Mathews' final appointments to the faculty before his retirement in 1952 were Shain, mentioned above, and C. Daniel Cornwell, who was a student with E. Bright Wilson at Harvard.[50]



Farrington Daniels (1889-1972)
U.W. Chemistry Faculty, 1920-1959
Chairman, 1952-1959

Mathews' success in building a widely-recognized department was unusual. Yet, even he made mistakes. Perhaps the most conspicuous was sacking Henry Eyring in 1928. On the whole, however, his record was unusual. He became chairman of a seven-man department in 1919; he retired from a 25-man department. He took over a building constructed in 1905 and substantially enlarged in 1913, but shared with the School of Pharmacy and the State Chemist's Laboratory. He retired from the same building (still shared with pharmacy and the state chemist), but with substantial additions made in 1929 and 1939. Following retirement he became involved in planning further enlargements.

Farrington Daniels took over the chairmanship and continued until retirement in 1959. His administration saw little change in permanent faculty; Hall and Schuette retired in 1955; Robert West and Lawrence Dahl were added.[51] Daniels' regime was plagued, nevertheless, with threats of losses of key professors to other institutions. He was successful in fending off all such raids except for Professor Johnson, who made the decision to become head of the department at Stanford in 1960.

Daniels was also faced with a critical shortage of space and expended much energy toward funding further expansion and seeking ground for such expansion. Building was delayed beyond the end of his chairmanship, but the fundamental problems were becoming resolved by then. The department ultimately abandoned the building it had occupied since 1905 and started a new unit in the block across the street. Ground was broken in 1960 and the unit, later christened the J. Howard Mathews Chemical Laboratory, was occupied in 1962. A major high-rise addition, occupying a substantial portion of the remainder of the block, was completed in 1967. It is named the Farrington Daniels Chemistry Building. The 1905 part of the vacated building was razed and replaced by modern construction by the department of physics. The modified structure, now named Chamberlin Hall, is occupied by the physics department and the Pharmacy School.

Daniels' chairmanship was characterized by his intense activity outside departmental administration. In 1953 he served as President of the American Chemical Society. He also maintained his heavy program of research which involved, in the years following the end of the war, the development of nuclear reactors for power production and a survey of mineralogical sources of fissionable materials. He soon became disenchanted with nuclear energy as a stable source of energy for the future when his survey showed that uranium sources in the earth's crust were limited. He then turned his enthusiasm toward solar energy as a limitless energy source. During his retirement he continued his investigations of solar energy problems to within a few weeks of his death in 1972.

When Daniels took the chairmanship he did so only on condition that the duties not seriously interfere with his scientific program. A precedent was set in the university at that time by permitting him to appoint an associate chairman to relieve him of some of the administrative duties, a policy which has been followed ever since in the department and which has been copied in certain other departments. Professor Holt served as associate chairman during the Daniels chairmanship and the following one of Ferry. When Shain took the chairmanship in 1967 he brought Alex Kotch into the department as associate chairman.[52] Kotch, with an organic Ph.D. under Carl S. Marvel at Illinois, had recently served in Washington as a grant administrator with the National Science Foundation. Kotch continued as associate chairman when Shain became Vice-Chancellor of the Madison unit of the University in 1970. He served successively under three chairmen, Shain, Willard (1970-72), and Fenske (1972-77).

Richard Fenske had joined the inorganic and physical divisions in 1961, fresh from a Ph.D. at Iowa State where he worked on energy levels of platinum under Donald S. Martin. Fenske, who was involved in the freshman chemistry program, also pursued an active research program involving calculation of energy levels and electronic transitions in transition-metal complexes. After ten years at Wisconsin he was chosen for the chairmanship.

When Fenske left the chairmanship, Kotch also resigned the associate chairmanship to take an administrative position with the newly formed Solar Energy Research Institute in Golden, Colorado. Thereupon, the new chairman, Dennis Evans who had joined the analytical division in 1966, selected Professor Larsen for the associate chairmanship. Larsen continued in this position when Barry Trost became chairman in 1980.[53]

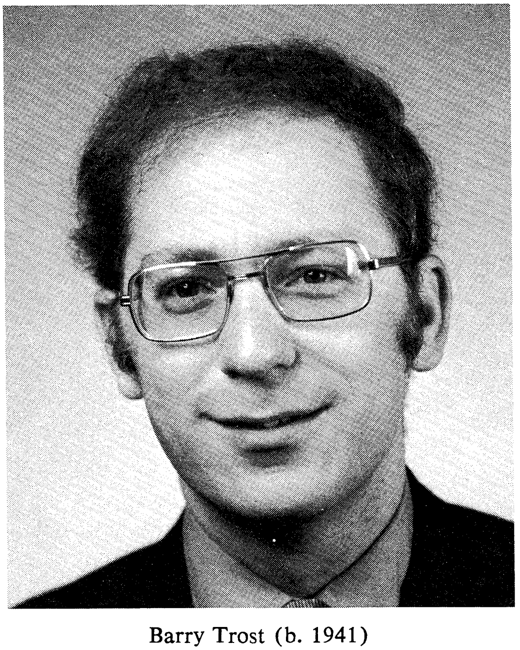
As the present is approached, an in-depth examination of the development of the chemistry department will not be continued. Suffice it to say that the decade of the sixties was characterized at first by rapid growth in personnel and activities consistent with a period of a strong economy which stimulated college enrollments all over America, and followed by a collapse which forced colleges everywhere to engage in a holding action which would enable them to at least maintain the position they had attained. This pattern was to continue through the seventies.

The story in the chemistry department at Wisconsin paralleled the pattern within other U.W. departments and in universities elsewhere. A rapid expansion in personnel and space took place in the sixties; a holding action characterized the seventies.

In the period between 1960 and 1969 the chemistry department added 25 men who attained tenured professorial status. Several of them came at tenure level to strengthen areas in the program, a departure from the long and successful tradition of bringing in promising young men in the hope that they would develop into leaders in the profession. Howard Zimmerman, a Yale Ph.D. in organic, was brought in from a tenured position at Northwestern in 1960; Richard Bernstein (physical and theoretical) was attracted from Michigan in 1963 (but was later attracted to Texas and then, Columbia); Emory Fisher (extension and general) returned to his doctoral alma mater from the Missouri School of Mines to take over supervision of chemistry and physics in the Extension Centers while helping in Madison with the freshman program; and Kotch (organic) came from the National Science Foundation.[54] During the sixties 14 professors were lost, one by death, four by retirement and nine to other universities. During the next decade, only 7 new men attained tenure and 5 tenured members were lost, two of these by retirement.

The chairmanship, following Daniels' retirement, turned over at fairly short intervals. The first three chairmen served a total of 72 years; the next five served 25. All of them were able men, but times had changed. The job of administering a department had become vastly more demanding by 1950 than it had been even in 1919, when Mathews became chairman. Further, all of the chairmen since Mathews were chemists with vigorous research programs who were unwilling to see their discipline pass them by, as had happened to Kahlenberg and Mathews.

The year 1980, which marked the department's one hundredth year as an administrative entity, was strikingly in contrast with 1880 when the discipline was given independent status. In 1880, all branches of chemistry were taught by a single professor, W. W. Daniells, who emphasized classical analytical methods in a building constructed to serve all the sciences. When he turned over the chairmanship to Louis Kahlenberg in 1907, the department had a faculty of four professors, several instructors and teaching assistants, a handful of graduate students, and a small but healthy research program. Kahlenberg clearly changed the department from one that was teaching-oriented to one that also emphasized research. This trend was continued under the Mathews' chairmanship and those that followed. In 1980 Trost became chairman of a department with 40 professors, a group of technicians and specialists, several hundred graduate students and postdoctoral fellows from most states of the union and numerous foreign countries, and several thousand undergraduate students. Bachelors' degrees have been granted in chemistry to more than 2250 students; Ph.D.'s number about 1675 since the first in 1899. The department graduates 30 to 50 undergraduate majors per year, many of whom go elsewhere for graduate studies while many go into industry or turn to medicine, or sometimes law. About half of the Ph.D.'s go into industry while many of the rest go into academic work, either directly or after a year or two of postdoctoral work elsewhere. By contrast, in



Barry Trost (b. 1941)
U.W. Chemistry Faculty, 1965-
Chairman, 1980-

1880 there was virtually no demand for chemists since chemical industry was barely emerging as a business field.

Acknowledgment

This paper has been drawn from material in the published literature, from the University of Wisconsin Archives and the Archives of the State Historical Society of Wisconsin, and from personal observations, first as a chemistry course student beginning in 1927, and later as a faculty member beginning in 1942. I am particularly indebted to many individuals who, over a half century, have passed on oral information, provided interpretation, and provided references to documentary sources. To them I am eternally grateful, and apologetic for any misinterpretation I may unwittingly have introduced.

To Henry A. Schuette I am most deeply indebted since he laid the foundations of my interest in the history of the department and, had it not been for a breakdown in health, expected to write this story. I also owe much to J. Howard Mathews, Farrington Daniels, F. C. Krauskopf, V. W. Meloche, J. W. Williams, E. B. Fred, Otto Kowalke, Homer Adkins, Richard Fischer, and Mark Ingraham. Others who have been helpful in settling various points include S. M. McElvain, Louis Kahlenberg, J. H. Walton, M. L. Holt, E. M. Larsen, Emory Fisher, Odell Taliaferro, Bette Germann, Harold Schimming, Edmund Fitchett, Fredus N. Peters, Jr., and Marion Veazey.

There are four histories of the university which also proved very useful for general background as well as certain specifics. They are: C. W. Butterfield, *History of the University of Wisconsin* (Madison, 1879), R. G. Thwaites, ed., *The University of Wisconsin. Its History and Its Alumni* (Madison, 1900); J. F. A. Pyre, *Wisconsin* (New York, 1920); M. Curti and V. Carstensen, *The University of Wisconsin,* 1848-1925, 2 vols. (Madison, 1949). In addition there were several less comprehensive works which were useful: Robert E. Gard, *University Madison U.S.A.* (Madison, 1970) has a wealth of nostalgia and anecdotal material; A. G. Bogue and Robert Taylor, eds., *The University of Wisconsin. One Hundred and Twenty-five Years* (Madison, 1975), contains chapters dealing with various aspects of the university, especially programs, mostly since 1949; *A Resourceful University. The University of Wisconsin-Madison in its 125th Year* (Madison, 1975) also deals with university programs with emphasis on recent developments.

Notes

[1] There have been four major evaluations of quality of graduate education in the U.S.; the first in 1925, the most recent in 1969. The U.W. chemistry department was ranked 13th in 1925, 5th in 1957, tied for 7th with Columbia in 1964, and tied for 8th with Chicago, and Cornell in 1969. Wisconsin biochemistry ranked 4th with Rockefeller U and MIT in 1964, 5th in 1969, in the only reports which ranked biochemistry and chemical engineering. In the latter field Wisconsin was ranked in a first place tie with MIT in 1964, and held first place alone in 1969. For the full reports see: R. Hughes, *Quality of Graduate Education in Thirty-eight Universities* (Washington: Am. Council on Educ., 1928); H. Keniston, *Graduate Study in the Arts and Sciences at the University of Pennsylvania* (Philadelphia: U of Pennsylvania, 1959); A. M. Cartter (Washington: Am. Council on Educ,. 1966); K. D. Roose and C. J. Anderson, *Rating of Graduate Programs* (Washington: Am. Council on Educ., 1970); for summary see A. J. Ihde, "Chemistry in the Old Northwest," *Ohio Journal of Science,* 78:59-69 (1978).

[2] Merle Curti and Vernon Carstensen, *The University of Wisconsin. A History, 1848-1925,* 2 vols. (Madison, 1949), 1:70-86. This reference will be cited hereafter as Curti-Carstensen with volume and page. Also see A. J. Ihde and H. A. Schuette, "The Early Days of Chemistry at the University of Wisconsin," *J. Chem. Educ.,* 29:65-72 (1952). Cited hereafter as Ihde-Schuette with page.

[3] On Lathrop see P. W. Boutwell, "Stephen Pearl Lathrop," *Trans. Wis. Acad.* 41:95-116 (1952). On Carr see Curti-Carstensen, 1:83-114, 177, 180-81; J. F. A. Pyre, *Wisconsin* (New York, 1920), 133-36. On Davies see Curti-Carstensen, 1:335, 355; and J. F. Parkinson, "John Eugene Davies," *Trans. Wis. Acad.,* 13:614-18 (1901).

[4] Curti-Carstensen, 1:172-73, 207 ff, 296.

[5] W. H. Glover, *Farm and College. The College of Agriculture of the University of Wisconsin. A History* (Madison, 1952), 30-31 and *passim;* Curti-Carstensen, 1:335, 352-53, 461-65; *Dictionary of Wisconsin Biography* (Madison, 1960), 94; Ihde-Schuette, 66-67.

[6] Curti-Carstensen, 1:246-74, 327-63, 439-75.

[7] W. H. Glover, *Farm and College* (Madison, 1952), 113-32, 160-86; Curti-Carstensen, 1:475 ff, 546-47, 11:386-94.

[8] Curti-Carstensen, 1:501-60.

[9] Ihde-Schuette, 67; *American Men of Science,* 1st edn., 1906: 148; 7th edn., 1944: 814; Chemistry Dept. files.

[10] N. F. Hall, "A Wisconsin Chemical Pioneer—The Scientific Work of Louis Kahlenberg," *Trans. Wis. Acad.,* 39:83-96 (1949) and 40:336-37 (1950); A. J. Ihde, *Dictionary of Scientific Biography,* 7: 208 (1973); A. J. Ihde, *American Chemists and Chemical Engineers,* W. D. Miles, ed. (Washington, 1976), 259. This work will be cited hereafter as Miles, *American Chemists.*

[11] Ihde-Schuette, 67; *American Men of Science,* 5th edn., 1933:676, 981.

[12] M. M. Vance, *Charles Richard Van Hise. Scientist Progressive,* (Madison, 1960), 91-136; Curti-Carstensen, 11:3-122.

[13] University of Wisconsin Catalogs, 1900-1920.

[14] "Faculty Resolution on the Death of Victor Lenher," U.W. Faculty Min. for June 17, 1927; *Ind. Engr. Chem.,* News Edn., 13:5 (1927); *Wis. State J.,* June 13, 1927 and June 14, 1927.

[15] Ihde-Schuette, 67-68.

[16] A. J. Ihde, "Kahlenberg's Opposition to the Theory of Electrolytic Dissociation," *Selected Topics in the History of Electrochemistry,* Geo. Dubpernell, *et al.,* eds., *Proceedings of the Electrochemical Society,* 78-6:299-312 (1978); R. G. A. Dolby, "Debates Over the Theory of Solution," *Hist. Studies in the Physical Sciences,* 7:297-404 (1976).

[17] On Walton see U.W. Faculty Resolution on Death of James H. Walton, Document 818, Oct. 6, 1947; *Capital Times,* June 7, 1947, June 8, 1947. On Krauskopf see U.W. Faculty Resolution on the Death of Francis C. Krauskopf, Document 835, Jan. 12, 1948. *Capital Times,* Oct. 16, 1947.

[18] Curti-Carstensen, 1:630; 11, 311, 348-51.

[19] Robert C. Nesbit, *Wisconsin. A History* (Madison, 1973), 435-55; Wm. F. Raney, *Wisconsin. A Story of Progress* (New York, 1940), 300-05, 308-16; Richard N. Current, *Wisconsin. A Bicentennial History* (New York, 1977), 54, 198-200.

[20] U.W. Archives, 4/0/3, box 76, "Round Robin"; Curti-Carstensen, 11, 311, 348-51.

[21] Curti-Carstensen, 11:349-51; H. C. Bradley to Van Hise, Nov. 18, 1918, presidential papers

[22] Miles, *American Chemists,* 5-7, and *Badger Chemist,* No. 4, p. 15; No. 10, p. 5; No. 14, p. 11; No. 16, p. 1; No. 17, pp. 1-2; No. 18, pp. 1, 3-6. Badger Chemist, which will be cited frequently hereafter, needs a bit of clarification. It is a printed newsletter of the U.W. Department of Chemistry in Madison which is prepared annually for alumni and friends of the department. As such it seldom finds its way into permanent repositories. A full set is on file in the Archives of the U.W. in Madison, in the Chemistry Department, and in the library of the author. It was edited from 1953 (No. 1) through 1964 (No. 11) by Henry A. Schuette, from 1965 (No. 12) through 1969 (No. 16) by Emory D. Fisher, and from 1970 (No. 17) through 1980 (No. 27) by Aaron J. Ihde. Issues carry news of the department, faculty, and alumni, including pictures. Nos. 1, 2, 16, 17, and 20 carry pictures of faculty groups and No. 4 has pictures and biographical profiles of each faculty member. As new persons joined the faculty, the next newsletter carried a picture and brief biography. This reference will be cited hereafter as *Badger Chemist,* with issue number and page. There have been annual issues except in 1962. Attention is also called to Alan J. Rocke and A. J. Ihde, "A Badger Chemist Genealogy," *J. Chem. Educ.,* 56:93-95 (1979), which traces the intellectual lineage of tenured professors back to C. L. Berthollet, A. F. Fourcroy, and J. J. Berzelius.

[23] F. Daniels, "Homer Burton Adkins," *Biog. Memoirs, Nat'l. Acad. Sciences,* 27:293-317 (1952); A. J. Ihde, *Dict. Amer. Biog.,* Fourth Suppl., 1946-1950 (1974), 5-7; Ihde in Miles, *American Chemists,* 5-7; Memorial Resolution, U.W. Faculty, Document 918, Nov. 7, 1949.

[24] *Badger Chemist,* No. 20, pp. 5-6; No. 22, p. 13; No. 26, p. 13.

[25] On Fischer see E. R. Schierz in Miles, *American Chemists,* 154-155 and *Badger Chemist,* No. 3, p. 5. On Klein see *Badger Chemist,* No. 4, p. 13; No. 8, p. 5; No. 12, p. 7.

[26] Olive Bell Daniels, *Farrington Daniels. Chemist and Prophet of the Solar Age* (Madison, 1978). Privately printed by the author. Also see A. J. Ihde in Miles, *American Chemists,* 319-20; *Badger Chemist,* No. 1, p. 1; No. 2, p. 1; No. 4, p. 6; No. 20, pp. 1, 3-4, 8-9.

[27] *Badger Chemist,* No. 4, p. 24; No. 16, pp. 10-11; No. 17, pp. 2-4; No. 24, p. 15.

[28] *Ibid.,* No. 4, p. 18; No. 7, p. 4; No. 20, p. 13.

[29] *Ibid.,* No. 4, p. 21; No. 5, p. 17; No. 9, p. 5; No. 15, p. 12; No. 18, pp. 19-20.

[30] *Ibid.,* No. 4, p. 10; No. 19, pp. 1, 3-4.

[31] *Ibid.*, No. 22, p. 14.

[32] *Ibid.*, No. 3, pp. 1-3; No. 4, p. 8; No. 10, p. 8.

[33] *Ibid.*, No. 3, pp. 1, 3; No. 4, p. 19; No. 5, p. 15; No. 15, pp. 1-2; No. 25, 1, 4-6.

[34] *Ibid.*, No. 4, p. 24; No. 6, p. 9; No. 9, p. 16; No. 18, p. 8; No. 26, pp. 1, 7, 19-20.

[35] Harold Schneider, "Harry Steenbock (1886-1967)—A Biographical Sketch," *J. Nutrition,* 103: 1235-47 (1973); A. J. Ihde, "Harry Steenbock-Student and Humanist," *Wis. Acad. Rev.,* 26/1: 15-17 (1979); H. F. DeLuca, "The Vitamin D Story," *ibid.,* 18-24; Memorial Resolution . . . on the death of Harry Steenbock, U.W. Faculty Document 186, March 4, 1968.

[36] *Badger Chemist,* No. 20, p. 11; No. 21, p. 11.

[37] *Ibid.*, No. 21, p. 4; No. 26, pp.11-12; Memorial Resolution . . . on the death of Karl Paul Link, U.W. Faculty Document 399, May 5, 1980.

[38] *Badger Chemist,* No. 4, p. 9; No. 9, p. 16; No. 13, pp. 15-16; No. 23, p. 5.

[39] *Ibid.*, No. 4, p. 23.

[40] *Ibid.*, No. 4, p. 12.

[41] *Ibid.*, No. 4, p. 2; No. 24, p. 2; No. 26, pp. 1, 5, 15-16.

[42] *Ibid.*, No. 4, p. 14; No. 15, p. 8; No. 23, p. 10; No. 27, p. 5.

[43] *Ibid.*, No. 4, p. 11; No. 14, pp. 14-16; No. 16, pp. 13-16; No. 27, pp. 15-17.

[44] *Ibid.*, No. 21, pp. 1, 3; No. 22, p. 19.

[45] On King see *ibid.,* No. 4, p. 12. On Margrave see *ibid.,* No. 4, p. 17; No. 10, p. 1; No. 27, p. 19.

[46] *Ibid.*, No. 4, p. 3; No. 25, p. 19; No. 26, p. 14; No. 27, p. 12.

[47] *Ibid.*, No. 4, p. 20; No. 15, p. 3; No. 16, p. 1; No. 18, p. 28; No. 22, p. 7; No. 24, p. 20; No. 25, p. 10.

[48] On Goering, see *ibid.,* No. 4, p. 8; No. 19, p. 12. On van Tamelen see *ibid.,* No. 4, p. 22.

[49] *Ibid.*, No. 4, p. 7; No. 7, p. 3; No. 16, p. 1; No. 19, p. 3.

[50] On Alberty, see *ibid.,* No. 4, p. 1; No. 14, p. 3. On Curtiss, *ibid.,* No. 4, p. 4. On Cornwell, *ibid.,* No. 4, p. 1.

[51] On Dahl, see *ibid.,* No. 7, p. 5; No. 25, p. 19. On West, see *ibid.,* No. 5, p. 5; No. 18, p. 15; No. 27, p. 13.

[52] *Ibid.*, No. 15, p. 7; No. 24, p. 10.

[53] On Fenske, see *ibid.,* No. 11, p. 8; No. 19, p. 12; No. 23, p. 5. On Evans, see *ibid.,* No. 14, p. 7; No. 23, p. 5. On Trost, see *ibid.,* No. 13, p. 7; No. 23, p. 12; No. 27, pp. 1, 8.

[54] The running record in the sixties is covered in *Badger Chemist,* Nos. 9-17 while Nos. 18-27 cover the decade of the seventies. On Zimmerman, see *ibid.,* No. 9; p. 4; No. 21, pp. 6-7; No. 23, p. 7; No. 27, p. 1. On Fisher see *ibid.,* No. 11, p. 9; No. 17, pp. 3-4. On Bernstein, see No. 10, p. 4; No. 21, p. 12.

FURTHER LINKS IN THE CALIFORNIA-WISCONSIN ASTRONOMICAL CONNECTION

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There are numerous astronomical links between California and Wisconsin, probably more than between any other two states. Many of them I outlined in a paper previously published in these Transactions,[1] but I have since learned of still more connections which are described in the present paper.

It all began with Lick Observatory, the first large research observatory in California. Its first Director, Edward S. Holden, came from the University of Wisconsin to Lick and thus started the California-Wisconsin axis. Holden was tentatively selected as Director of Lick Observatory in 1874, many years before it was built on Mount Hamilton, while he was still a young astronomer at the Naval Observatory in Washington. Holden left the Naval Observatory to become Director of the Washburn Observatory on the Madison campus of the University of Wisconsin in 1881 when James Watson, its first Director, died unexpectedly of pneumonia.

At Washburn, with the 15½-inch refractor and the meridian circle, Holden observed positions of nebulae, stars and comets—the old astronomy of position. In 1883 he headed a government-sponsored eclipse expedition to Caroline Island, a tiny atoll in the Pacific Ocean between Tahiti and Hawaii. It was a three-month trip, in which he and the other astronomers travelled over 12,000 miles by ship and railroad. They had to cross the Isthmus of Panama and change ships in those days long before the canal had been built. At the eclipse Holden searched visually for a planet closer to the sun than Mercury, but found none.[2]

Holden advised Nils P. Haugen, then Wisconsin Commissioner of Railroads, on introducing a bill in the legislature to require the railroads to use Central Standard Time in the state.[3] Up until then there was a twenty-minute difference between Chicago and St. Paul times, and the railroads changed time at Elroy. Holden was one of the professors who approached T. C. Chamberlin, then with the United States Geological Survey, about succeeding John Bascom as President of the University of Wisconsin. Chamberlin was interested in the position, but did not want to force Bascom out, and therefore did not actually become President until after Holden had left for California.[4]

Holden was a member of the Wisconsin Academy of Sciences, Arts, and Letters, and gave a paper on the Caroline Island eclipse expedition at the W.A.S.A.L. meeting in Madison on December 28, 1883. After he departed for California, he became a corresponding member of the Academy.[5] When he left Wisconsin, Holden presented several books and pamphlets to the State Historical Society of Wisconsin, and also "a maro, or covering of the loins, used by natives of Tahiti . . . of both sexes, usually their only garment."[6]

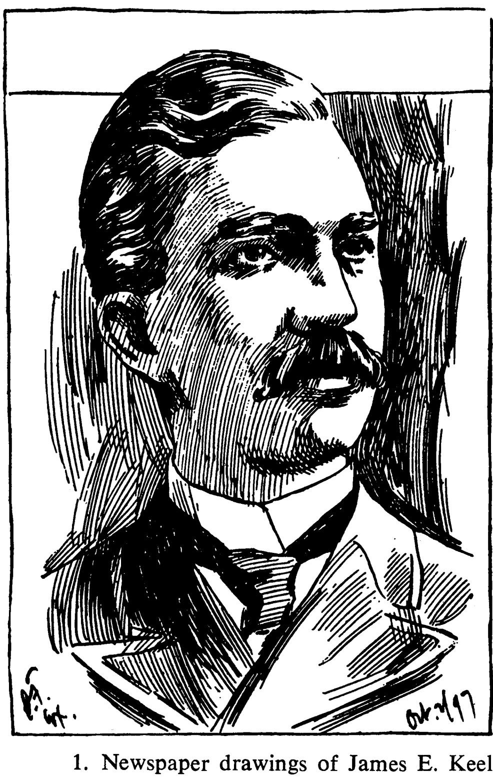
Holden enjoyed life in Madison and left only because of the outstanding astronomical opportunity at the new Lick Observatory. He wrote to B. A. Gould, a prospective successor in his job as Director at Washburn:[7]

> Let me ask you to consider this letter as strictly confidential. I expect to resign my position here on Jan 1/86, to take the L[ick] O[bservatory]. I wish to know if you have any desire to take this Observatory. If you would be willing I shd. like to be the means of having it offered to you. With the exception of the H[arvard] C[ollege] O[bservatory]. I regard it as the most desirable college Obs.

in the U.S. The salary is $3000 with a beautiful house (fifteen rooms) near the O. with every possible convenience. The O. itself is completely fitted for ast'y of position. The state publishes the obsns. The college duties are 50 lectures of 1 hour, April-June. The observatory income is 1500 (app'n) 175 (lib'y) 600 (time service). Out of this I pay a fair asst (720) computer (360) janitor (420), and meteor. obsr. (quarters) & all expenses. The site of the Obsy & of the House is extremely beautiful. The town itself is very pretty. There is no reason why your children could not get all the Essentials of education here. The liberty of the Astromr. is absolute. I am well aware that you deserve something more than this Obsy. But I know that if you took it you wd. make it what you deserve. I am not willing that it should go to another if you are willing to take it. May I ask you for a word to express your wishes on this?

In California as Lick Observatory approached completion, Holden was brought out as President of the University, a job that was often open in those years. He started as President in January 1886 and served until the observatory was finished and ready for use in 1888, at which time he stepped up to its directorship. Holden received an honorary LL.D. degree from the University of Wisconsin in 1886, just after he left for California, thus enabling his friends from then on to address him as "Doctor."[2]

A considerable amount of planning for Lick Observatory had been done under Holden's recommendations while he was at Madison. He did much of it himself, particularly on the library and on the smaller astronomical instruments, but other parts of it were done by his colleagues on the University of Wisconsin faculty. The report on the



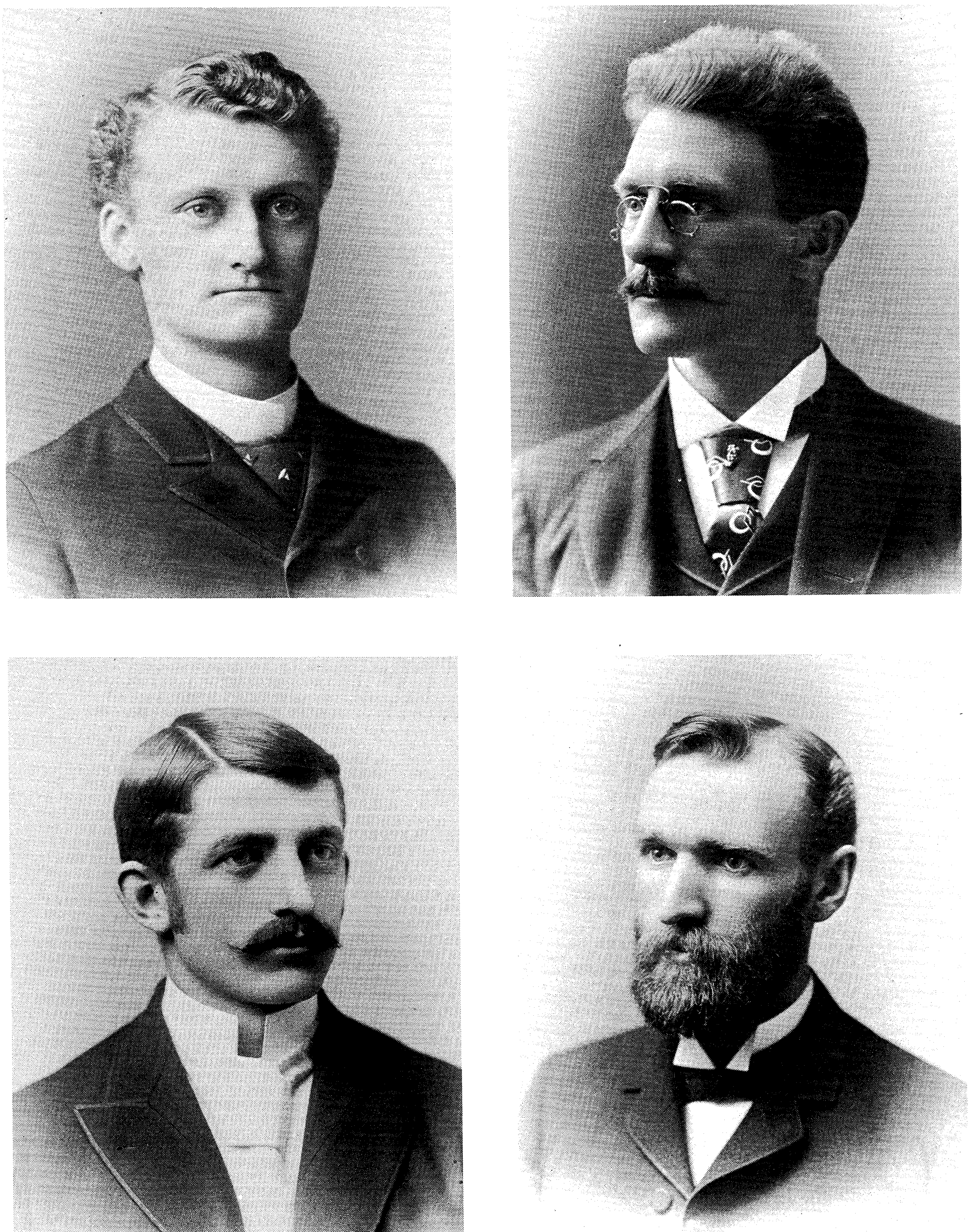
1. Newspaper drawings of James E. Keeler (left) and Edward S. Holden (right), second and first Directors of Lick Observatory, respectively. Holden began and Keeler nurtured the California-Wisconsin astronomical connection. Lick Observatory Archives.

geology of Mount Hamilton, published in Volume I of the Lick Observatory Publications, is signed by Roland D. Irving, Professor of Geology at the University of Wisconsin and United States Geologist in Madison.[8] This report was drawn up by his assistant, young Charles Van Hise, later the recipient in 1892 of the first earned Ph.D. degree ever granted by the University of Wisconsin. Van Hise succeeded Irving as Professor of Geology at Madison, and still later became President of the University of Wisconsin from 1903 until his death in 1918. He was the popularizer of "the Wisconsin idea" of the university as the practical servant of the state.[9]

The detailed design of the dome for the Lick Observatory 36-inch telescope, a large and very unusual building for its time, was provided by Storm Bull of the University of Wisconsin Mechanical Engineering Department. He also designed the focal plane baseplate for the telescope, used for mounting the eyepieces and the spectrograph.[10] Born in Norway, Bull was trained at the Swiss Polytechnic Institute in Zurich. He emigrated to Madison in 1879, where his uncle, Ole Bull, the famous violinist, was then living, and joined the University of Wisconsin faculty. Throughout his career Bull did outside consulting and also served as a full-time engineering faculty member. He charged the Lick Trustees 75¢ an hour for his services, which he regarded as a mean between the $1.00 per hour that would be a fair price and the 50¢ per hour Holden wanted to pay him.[11] As a University of Wisconsin faculty member, Bull was elected to the Madison City Council and was Mayor of Madison for one term.[12]

George C. Comstock was with Holden one of the early prime movers in the California-Wisconsin axis. Comstock was born in Madison and studied astronomy at the University of Michigan, where he received his B.S. degree in 1879. When Watson moved from Michigan to the University of Wisconsin as first Director of its Washburn Observatory, Comstock went with him and after Watson's death, Comstock stayed on as Holden's assistant. At Madison he calculated under Holden's supervision many of the tables to be used later at Lick Observatory for the reduction of star positions, the determination of time, etc. In 1885 Comstock left Madison to become Professor of Mathematics and Astronomy at Ohio State University, but he spent the summer of 1886 at Lick Observatory, working with the meridian circle before the 36-inch refractor was completed. Holden thought very highly of Comstock's scientific abilities and wanted to hire him on the Lick staff,[13] but Comstock preferred the job as Holden's successor at Madison.

When he accepted the Presidency of the University of California, Holden had first thought of his friend Samuel P. Langley, a pioneer astrophysicist then at Allegheny Observatory near Pittsburgh, as his successor as Director at Washburn. Langley had visited Madison and appreciated it greatly, writing Holden, "I look back to Madison as a home in sunshine, part of whose joys have been intercalated into my bachelor existence, and I shall long remember my visit, which was not only so pleasant at the time but which has done me good since. . . ."[14] Langley, however, declined to be considered for the directorship at Washburn Observatory, telling Holden that he did so for only one reason. He said he was over fifty and wanted to keep working, "but I yearn—it is the word—for a larger companionship, and for the society of the East which you are—with wife and children *and* your work able to leave for a larger scientific field."[15] Holden next offered to recommend for the job in succession two friends of his own generation, B. A. Gould and William A. Rogers. Gould declined,[16] but Rogers wanted the job, as long as he did not have to appear as a candidate for it. He was actually recommended for the position by President John Bascom, who however was himself nearing the end



2. Four important figures in the California-Wisconsin astronomical network. George C. Comstock (upper left), Storm Bull (upper right), Sidney D. Townley (lower left), Charles R. Van Hise (lower right). Lick Observatory Archives.

of his reign and was under pressure to resign. The Board of Regents did not accept the recommendation, but instead put Physics Professor John E. Davies in temporary charge of the observatory. Rogers then accepted a position at Colby College in Maine.[17] A year later Comstock was appointed Director, but because of his relative youth, he was saddled by the Regents for the first few years with a "consulting director," Asaph Hall of the Naval Observatory. Hall would come to Wisconsin for just a few weeks each year, but this awkward arrangement soon ended when Comstock had gained the Regents' confidence.[18] Hall, the discoverer of Deimos and Phobos, the two satellites of Mars, himself had an earlier Wisconsin connection. He and his wife had been married at Elkhorn in 1856, while she was looking for a job as a school teacher.[19]

All Comstock's research was in positional astronomy. He was the first Wisconsin faculty member elected to the National Academy of Sciences for work done at Madison, and became the first Dean of the University of Wisconsin Graduate School, appointed by Van Hise in 1904. Comstock built up research at Madison over the years until he retired in 1920. As an assistant at Washburn Observatory, uncertain about his future, he had gone to law school and had entered the bar, but had never practiced. He always said that law school was the best training he ever had; possibly he meant for being a dean.[20]

Armin O. Leuschner was a California astronomer who did not quite make the Wisconsin connection. He became the first graduate student at Lick Observatory in 1888, after earning his B.S. at Michigan. But one year later when A. V. Egbert, Comstock's assistant at Washburn Observatory, left to take a position on the faculty of a small church college in northern Ohio, Comstock wrote Holden to ask if he could recommend a replacement.[21] Holden strongly recommended Leuschner, who wanted to come to Madison and spend a year away from Lick.[22] But by the time Holden's letter had arrived Comstock had opened negotiations with Albert S. Flint, an older, more experienced man from the Naval Observatory, and he hired him. Thus to California's good fortune Leuschner stayed in the West and ultimately became long-term Chairman of the Berkeley Astronomy Department, and for several years Dean of the University of California Graduate School.[23]

Sidney D. Townley, a native of Waukesha, received the first graduate fellowship at Lick Observatory, the Phoebe Hearst Fellowship, worth $360 a year. He did his undergraduate degree at Wisconsin, followed by two years of graduate work, leading to an M.S., all under Comstock. As an undergraduate Townley took part in all the student activities, including not only oratorical contests and class elections, but also hunting in the woods west of the city—now the West High School area—and rowing out to the University Farm to steal apples—near the present site of Eagle Heights. In his sophomore year Townley heard a lecture by a visiting English astronomer, Richard A. Proctor. It inspired him to take an astronomy course from Comstock, and the course interested him so much that in his junior year he got a job as Comstock's student observing assistant. This job paid 20¢ an hour and gave Townley the privilege of living in a furnished room at the Observatory, for which he paid $4 a month. As a senior he earned a little more by running the Observatory time service, which furnished the time to the railroads in Madison. His parents let him take the family horse to the University, since as part of his job he was allowed to keep it in the Observatory barn. The time service job tied him down in Madison so that he could not go home to Waukesha for vacations except for a few days at a time.

After finishing his B.S., Townley received one of four graduate fellowships at the University of Wisconsin, for which he taught one section of an algebra class supervised by Charles D. Slichter and continued to help at the Observatory. In the summer of 1891 Townley went to Oregon for a working visit with one of his brothers, and took the opportunity to make a quick tour of northern California. He visited Lick Observatory where he met several of the staff and watched them observe one night. He also stopped at Stanford University, which was still under construction but due to open that fall. Townley admired the handsome buildings and gave his opinion that "[t]his is the beginning of a fine University and will probably some day rank among the leading institutions of the land." Finally he visited Berkeley where he was less impressed: "The University has a nice location and some fine buildings but in neither respect does it come up to the U.W." After two years of graduate work at Madison, Townley received his M.S. and then on Comstock's recommendation went to Lick on the first fellowship, which paid $40 a year less than the fellowship he had held at Wisconsin.

According to Townley, he arrived at Mount Hamilton on the noon stage on July 1, 1892, the day his fellowship began, only to be reprimanded by Holden for not coming the day before so that he could begin work promptly at 9 A.M.[24] This is a good story, but actually Townley's diary showed that he was nearly three weeks late in addition to the half day he mentions. But once there he got right down to work and was able to spend much of the time in the summer and fall in research on variable stars, the subject of his Madison thesis. In addition, at Lick he had the duties of running the time service and of assisting Astronomer W. W. Campbell observe spectroscopically two nights each week. In the winter semester Townley moved to Berkeley and took formal classes, and then returned to Mount Hamilton in May and June to complete his observing project.[25]

The next year his fellowship was not renewed; Holden preferred to spend the money that Mrs. Hearst gave the Observatory to finance an eclipse expedition to Chile and to buy a new spectroscope for the Observatory.[26] In desperation Townley wrote Comstock asking if there was any possibility of a job at Wisconsin, or if he knew of any other jobs at other observatories: "I have got to strike something before long or else go to sawing wood for a living."[27] He literally dreamt of Madison.[28] Townley did get a low-paying instructorship at Michigan, and with one year of graduate study in Germany along the way ultimately received his Sc.D. at Ann Arbor in 1897.

Jobs were hard to come by; for instance as the directorship changed hands at Lick Observatory, Townley wrote five different letters of application for a position there within one two-and-a-half-year period.[29] He held an instructorship at Berkeley for several years, then became the one-man staff of a geodetic observatory at Ukiah, California and then at last became a long-time professor at Stanford, which had indeed turned out to be a fine university.[24]

One of the most famous scientists from the University of Wisconsin, Robert W. Wood, a physicist universally regarded as one of the world's experts in light, came to Lick Observatory as a guest investigator in the summer of 1900. He was then a young assistant professor and was introduced to James E. Keeler, Holden's successor as Director, in a letter from Benjamin W. Snow, Keeler's old friend and schoolmate.[30] Snow described Wood as "a thoroughly jolly and companionable man, and one who has won for himself a very enviable place among the investigators of our faculty."[31] Wood, after observing the solar corona at the 1900 eclipse, had conceived a scheme of detecting the faint corona without an eclipse. He

3. The University of Wisconsin baseball team of 1891. Sidney D. Townley, the manager, is in the back row, second from left, wearing a dark derby hat and light suit. Then an astronomy graduate student at Wisconsin, he later became a graduate student at Lick Observatory, and still later a professor at Stanford. Photograph courtesy of the Townley Family.

planned to take advantage of the fact that the coronal light is polarized and contains no absorption lines to enhance its contrast with the scattered sunlight.[32] Keeler died unexpectedly of a stroke just a few days after inviting Wood to bring his apparatus to Lick, and W. W. Campbell was actually in charge when he arrived. The corona, even in polarized light in the deepest solar absorption lines, proved too faint for Wood's method, as he had feared it might.[33] Nevertheless, the experiment at Lick was useful in evaluating the method, and Wood remained interested in astronomy and full of suggestions for further observational research. A year after his visit to Mount Hamilton Wood left Wisconsin when he was appointed a full professor at Johns Hopkins, in the vacancy created by Henry A. Rowland's death.[34]

Joel Stebbins, Professor of Astronomy at the University of Wisconsin from 1922 until 1948, earned the third Ph.D. ever awarded by Lick Observatory. He had been an undergraduate at the University of Nebraska, and spent one further year as a graduate student there, then another year at Wisconsin with Comstock who recommended he go to Lick to learn "the new astronomy" or astrophysical research. In California, in alternate semesters Stebbins participated in observational research at Mount Hamilton and took formal courses in Berkeley. During his second year at Lick, Stebbins began observing with the 36-inch refractor and did the first thesis assigned by Campbell, a busy research worker with many observational projects. Stebbins' thesis was on the long-period variable Mira. He followed its spectral changes and correctly concluded that it must be an intrinsic variable star, physically pulsating, and not a system of two stars revolving about each other.[35]

Stebbins had quickly learned that the California atmosphere was much better for astronomy than Wisconsin's when he saw a double star resolved with the small 12-inch refractor on Mount Hamilton that had seemed an elongated blob, only suspected of being double, with the giant Yerkes 40-inch refractor.[36] As Keeler had earlier written when he thought the 40-inch was going to be erected in Chicago, rather than in Williams Bay as it was, "Our Chicago friends will have a larger telescope, but 36 inches on Mt. Hamilton will beat 40 inches in Chicago."[37] And like many another Midwesterner, Stebbins thought California was beautiful in the spring when the mountains are sparkling green and the valleys are covered with flowers, but in late summer when the hills dried up and turned brown he wrote: "I can't make up my mind to think that this place is as pretty as Madison. Everything is so different."[38] In 1903, after only two years as a graduate student at the University of California, Stebbins earned his Ph.D. degree and then went on to a long and successful career in photoelectric research at Illinois and Wisconsin.[35]

Although Sebastian Albrecht was not a famous scientist, he holds the distinction of being the first astronomer ever married at Lick Observatory. Born in Milwaukee, he graduated from the University of Wisconsin in 1900, taught high school in West Bend for two years, then returned to Madison to begin graduate work in astronomy and mathematics. After one year as a graduate student, he was awarded a Lick Observatory fellowship on Comstock's recommendation.[39] For the next three years he divided his time between observational work at Lick and classes at Berkeley. He did his thesis, a spectroscopic study of Cepheid variable stars, under the supervision of W. W. Campbell, who was by then the third Director of Lick Observatory. (Campbell received an honorary LL.D. degree from the University of Wisconsin in 1902, as Holden had earlier.)[40]

Albrecht was appointed to the Lick staff after receiving his Ph.D. in 1906. He worked closely with Campbell taking spectroscopic measurements with the 36-inch refractor. They were trying to detect the presence of water vapor in Mars' atmosphere, or at least set an upper limit to its amount. Albrecht observed at Mount Hamilton and also accompanied Campbell on his expedition to Mount Whitney in the late summer of 1909. The party of six people included a doctor, a carpenter, and a meteorological expert from the Weather Bureau in addition to the astronomers and a guide. They took a 16-inch reflecting telescope, a prism spectroscope, and the associated optics to the 14,565 foot summit. After a few days of acclimatization for themselves and their horses at an intermediate altitude, in two nights at the summit they obtained several good spectra of Mars and the Moon, and although they did not detect water vapor, they set a firm upper limit to the amount of it in Mars' atmosphere.[41]

In 1910, Albrecht accepted a job at the Argentine National Observatory in Cordoba. Before his departure, Albrecht married Violet Standen, a Lick Observatory secretary. The wedding was held in the Director's house on Mount Hamilton with fifty members of the Observatory community in attendance. A minister from Saratoga, California, performed the ceremony under crossed flags of the United States and Argentina, the latter a flag borrowed by Campbell from the Consulate in San Francisco. The Albrechts left Mount Hamilton a week later for Argentina with intermediate stops at his family home on Forest Home Avenue in Milwaukee, and in New York.[42] Unfortunately, the job in Argentina did not work out, and Albrecht returned to the United States in 1912, working briefly at the University of Michigan and then for many years at Dudley Observatory in Albany, New York.[43]

In conclusion, there were and still are many close astronomical ties between Wisconsin and California, probably more than between any two states. In part, they came about because of the demand for astronomers in California—beginning in 1888 with the completion of the Lick Observatory—and because of the source of astronomers at the University of Wisconsin—from early on a strong research-oriented institution. But in part they also came about because of personal contacts and relationships dating back to Holden and Comstock—and those personal contacts were and are important too.

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