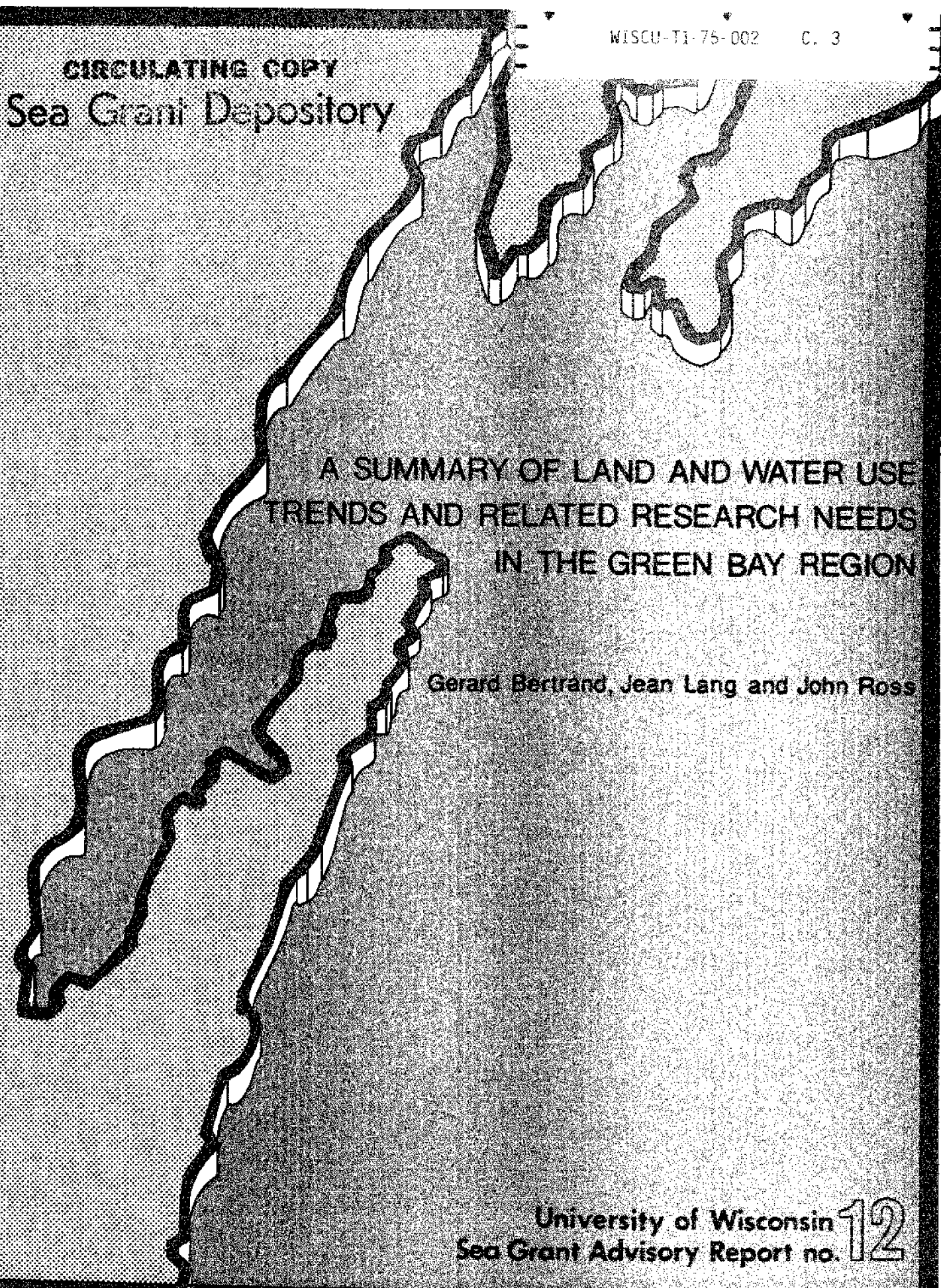


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**A SUMMARY OF LAND AND WATER USE
TRENDS AND RELATED RESEARCH NEEDS
IN THE GREEN BAY REGION**

Gerard Bertrand, Jean Lang and John Ross

University of Wisconsin
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A SUMMARY OF LAND AND WATER USE TRENDS AND RELATED RESEARCH
NEEDS IN THE GREEN BAY REGION

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UNIVERSITY OF WISCONSIN SEA GRANT COLLEGE PROGRAM

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The following summary is an abstract of a longer report entitled *The Green Bay Region: A Review of Water Related Problems in a Freshwater Estuary*.

The report was initiated by the University of Wisconsin Sea Grant College Program as a means of consolidating and reviewing what is known about Green Bay and its watershed and of determining where future research needs lie. This summary encapsulates the report's findings and recommendations.

By any definition, Green Bay is one of the nation's important estuaries. A major geographic feature of Wisconsin and Michigan, straddling the 45th parallel, the bay is a significant natural resource. It is a recreation area, a fishery, a commercial waterway, and it contains a highly productive biological system.

But it seems to have been taken for granted by men intent on their purposes.

Since the time of settlement — 150 years ago — the Green Bay system has been changed drastically. Whether for good or ill is a matter of opinion, but changed it has been. And the trends continue.

The changes are largely the result of two major activities:

- (1) Heavy use of resources in the region; and
- (2) Use of the surface water as a pollution sink, causing a progression of poor quality water up the bay from south to north as time goes on.

The interaction of resource use and pollution has caused a depletion of natural resources, including some that would have the capacity to renew themselves under less stress. But it has also vastly changed the population dynamics of an array of living species in the bay.

There are many examples of man's ability to change the natural scheme of things, and he probably doesn't give that much thought to the consequences of his actions until there is evident a series of gross changes in his own habitat. It is possible that a critical point of change is being reached in the condition of Green Bay.

The authors suggest it is time to ask a series of overview questions about Green Bay:

--Are the resource management and pollution control strategies we are currently using adequate and realistic in terms of the carrying capacity of the bay's system?

--Are amounts and rates of physical and biological change in the bay such that we are crossing thresholds of no return?

--Is Green Bay merely an appendix to Lake Michigan, isolated from the main lake, or will the pollution in the bay gradually infect the larger system?

--Considering that the bay is naturally shallow and nutrient rich, are our expectations for improved water quality in Green Bay reasonable?

--Are the problems of the bay unavoidable, or is the deterioration largely the result of our inaction?

This summary highlights what Green Bay is and what we know about the changes occurring there. Our intent is to describe things, not to pass judgment on the past or the future.

The Geographic Setting

Green Bay is 119 miles long and has an average width of 23 miles. Few areas of the bay have depths over 131 feet. Like Lake Michigan, it is a remnant of the last glaciation, so it is geologically young. Although Green Bay appears to be an appendage, almost isolated from Lake Michigan, it is a significant part of that Great Lake. About one-third of all the land that drains into the larger lake drains through Green Bay. Eleven rivers and streams enter the bay, but one stands out. The Fox River is the most significant because of its volume and because of its pollution load. The banks of the Fox are heavily industrialized and the river receives effluent not only from numerous factories and mills, but also from a population of approximately a half million people.

Water Movement

The water in the bay has several characteristics of signal importance in any management strategy:

- (1) The water level is now about 580 feet above New York mean sea level. This represents a dramatic increase from the level of ten years ago. The water level has fluctuated widely over the years. Since 1860 when records were started, there has been a variation of almost seven feet between extreme high and low levels. The long-term water level fluctuations are due to climatic variations. To a very limited degree the water levels can be controlled at the major inlet for Lake Michigan (Sault Ste. Marie) and through the southern outlet of the Chicago canal. But the process is extremely slow, and in light of current high levels would have an insignificant effect. Although levels have dropped slightly over the past year (1974), predictions are for levels to remain high or go even higher as the trend toward a wetter climate continues.
- (2) Because of its elongated shape, Green Bay is subject to basin oscillations on a short-term scale. These oscillations, or "seiches," are essentially caused by the earth's movement. However, they are modified and enhanced by wind, sudden changes in barometric pressure and other physical factors. A seiche may change water levels a foot or more in a few hours, six miles up from the mouth of the Fox River.
- (3) Currents in the lower bay tend to be counter-clockwise, moving southerly on the western side, then swinging east and north. There are some pockets in the lower bay with limited water movement.

While the water from Green Bay does find its way into Lake Michigan, the bay tends to have a hydrodynamic life of its own. When the water does exit, the outflow is carried south along the Wisconsin shore.

The Bay Bottom

The bottom of the bay varies from mud, through sandy mud, to sand, clay and rock. Since 1950, the lower bay has become much shallower, due to increasing rates of sedimentation. This deposit has reached a depth of four feet in some locations since 1950, with an average of two feet of deposit throughout the lower bay region.

The Fox-Wolf River basin is roughly 6,250 square miles and it is now estimated that each square mile contributes 40 tons of sediment to the bay each year. The natural characteristics of the bay, plus the rate of siltation mean:

- (1) Green Bay's shallow waters will continue to be turbid, and
- (2) Dredging will of necessity be a continuing practice.

Dredgings from the mouth of the Fox River and the inner ship channel contain polluted sediments. Authorized dredgings are now deposited in a series of marsh areas. Some landowners, however, carry out illegal dredge and fill activities in the area each year that violate permit regulations.

One other bay bottom feature could produce an environmental impact in the future. Research started in 1969 uncovered major manganese deposits in the form of small pellets in the upper bay. The deposits have a relatively low percentage of manganese compared to other freshwater deposits, and they are lacking in other trace elements that have commercial value. Present foreign sources of manganese are less expensive, but the Green Bay deposits can be considered a reserve and underwater mining is not out of the question. The special value of this deposit is that the manganese occurs in a pellet form, making it an ideal catalyst.

Water Quality

Two significant water quality problems stand out in Green Bay:

- (1) Dissolved oxygen levels, and
- (2) Nutrient enrichment, with accompanying algae production.

The Fox River outflow is the prime determinant of oxygen levels in the lower bay. In summer, the Fox is a source of oxygen-depleted water. Depressed oxygen levels extend from Appleton, through the lower Fox and out into the bay. Oxygen levels in that part of the bay drop to zero, and aquatic life decreases accordingly. Oxygen levels improve in the fall in the river and in the lower bay. In winter, a critically low oxygen level develops in the middle bay. There is some indication of improvement in oxygen conditions in the

last few years. This may be due to pollution abatement, but it may also be due to the diluting effect of increased water levels and thus the reduction of biochemical oxygen demand.

Man's activities have added significant amounts of nutrients (phosphates and nitrates) to the bay. Phosphates are critical in this situation. They are only part of the reason for the abundant growth of algae in the bay each spring through fall, but a decline in phosphates could limit algae growth.

In 1971, the summer algae bloom in Green Bay extended 15 miles up the bay from the mouth of the Fox River; in 1972, 20 miles; and in 1973, the bloom had extended 30 miles up the eastern shore. It is unknown how long this rapid rate of growth will continue.

Diatoms are a major component of the algae community and predominate during the winter and early spring. Beginning in May, the numbers of green and blue green algae increase, reaching a peak in late summer. Because of the high production of algae in the bay, the system could be described as overfed and aging rapidly.

There is no doubt that the nutrient loadings that come from the mouth of the Fox River are primarily responsible for the eutrophic (nutrient rich) condition of the lower bay. The lower Fox Valley is one of the most heavily populated and industrialized areas in the state. Even without the tremendous load of industrial and municipal enrichment, the water from Lake Winnebago above the industrial belt is already in a significantly degraded state and carries heavy nutrient loads. Much of that phosphorus comes from urban and rural runoff. Phosphate will continue to be a significant problem in spite of enforcement and pollution abatement action against industrial and municipal sanitary sewers. To solve the problem will require control of agricultural sources and urban runoff. As with phosphorus, nitrogen will continue to be a problem even after pollution abatement reduces nitrogen loadings from industrial and municipal forces, because farmland is a source and because the blue green algae fix nitrogen within the lower bay.

While oxygen and nutrients stand out as water quality concerns, there are a series of other issues that cannot be ignored, either because they might develop into a major environmental crisis or because they may be critical in terms of a chain effect in the environment.

- (1) Green Bay's ecosystem has been impacted by chlorinated pesticides. The drainage basin is a major agricultural area. Although pesticide levels appear to be below levels of major concern, they are sufficiently high to warrant continued monitoring to determine rates of decomposition within the system.
- (2) The potential problem of the industrial plasticizers known as polychlorinated biphenyls (PCBs) has not been adequately addressed for Green Bay. Like the chlorinated pesticides, PCBs appear to be concentrated in aquatic organisms, like fish and in bottom sediments. Preliminary studies on the bay and recent studies on southern Lake Michigan indicate that this environmental pollutant needs careful attention.

- (3) The western shore of Green Bay is low, with indistinct shorelines, and the area of its littoral zone contracts and expands with rising and falling water levels. A decade ago it was a broad band of aquatic vegetation extending from the city of Green Bay to Escanaba, Michigan. This classical littoral zone played host to a horde of waterfowl, aquatic birds and mammals, as well as a complex community of plankton and nekton. This habitat has been drastically diminished under the recent high water levels, and with it, the associated animal community. While the biological recovery of this zone is not a long-term problem, man's manipulation of the shoreline during this period of high water could do much to postpone recovery. Whatever one might say pro or con about present water levels, there is no question that the current habitat loss is exceedingly heavy.

The littoral zone can also be described in this area as a tension zone for man. To the extent that there is development in this area, both high water and low water cause problems. In periods of low water, there is anger over regulations against dredging and during times of high water, there is argument over shoreline fills and erosion protection structures.

Biological surveys of Green Bay show that the lower bay is heavily polluted and the middle bay has gone from lightly to moderately polluted. This evidence comes primarily from studies of benthic organisms — creatures that live on lake or river bottoms. While they are not necessarily in themselves a water quality issue, these animals are good indicators of water conditions because their kinds and numbers change with the changing environment. Even minor changes can be measured. In Green Bay there is no need to search for subtle changes. The gross effects of the Fox River system are strongly reflected in the benthic zone. The first quantitative survey of benthic organisms was taken in lower Green Bay in 1938 and 1939. By the time of the next major survey in 1952, there had been a dramatic increase in the number of pollution-tolerant worms. Additional work in 1971 showed that a steady encroachment of polluted conditions up the bay and along the eastern shore had occurred.

It is clear that Green Bay is following the path of Lake Erie and that many of the changes earlier documented in Lake Erie are now occurring in Green Bay. Benthic fauna can continue to serve as a significant indicator of the progress or regression of polluted conditions in the bay.

Status of Resources

Of the resource-based industries in the watershed, we have considered only those with significant impact on the bay. Thus there is no discussion of machine manufacturing or several other important industries of the region.

(1) Fisheries

Commercial fish stocks were once far larger and more diverse than at present. Herring and whitefish inhabited the shoals throughout the bay. Trout occurred in the deeper, colder waters of the northern bay. Walleyed pike, pickerel, sturgeon, suckers, bass, perch and catfish swam the shallow marshy

waters at the heads of bays and mouths of rivers. This distribution began to undergo changes as early as 1850. Fishermen who located a large population of fish would simply fish until the stock was used up.

Pollution was also an early factor. In 1880, a writer noted a large mass of sawdust, two miles broad and many miles long, floating about in the bay. Perch catches were on the decline by 1900. The lake herring catch peaked around 1905. And when, in the early 1900s, the economic focus of the region shifted from lumber cutting to papermaking, there followed fish die-offs as pulp wastes reduced oxygen levels in the lower Fox River and lower Green Bay.

Up until the 1920s the depletion of fish stocks was a story of pollution and removal of habitat, overfishing and the vagaries of the physical environment. But another factor was added in the 1920s — introduction of exotic species. The first troublesome newcomer was the German carp, planted throughout the state in the 1880s and 1890s. Today it is well established along the shallow, western shore. Following the carp came the adaptable ocean smelt; then came invasions of the sea lamprey and the alewife through the St. Lawrence Seaway.

Throughout the 1950s and 1960s, the fisheries could only be described as ailing. Lamprey control and the introduction of salmon and trout have since given a base for sports fishing in the states bordering Lake Michigan, but most of this activity is out on Lake Michigan proper. As of 1974, lake trout were still not reproducing themselves. Both salmon and lake trout populations remain dependent on yearly restocking programs — they are there only by the grace of state and federal revenues. Today the Green Bay commercial fishery depends largely on the harvest of alewife for fish meal and other purposes and on the whitefish harvest in the northernmost reaches of the bay.

Recreational fishing on lower Green Bay is now poor. The northern bay is a more popular sport fishing area and holds more promise for the future. Given optimum environmental conditions, it might take generations to reestablish the once grand array of natural fish. Today, throughout the Lake Michigan area, fish management policies reflect the belief that the need to develop immediate economic opportunities, such as sport fishing facilities, overrides the longer-range need for rehabilitation of a balanced fishery that could provide both sport and food. There is obviously room on Green Bay for both commercial and sport fisheries, given the opportunity. Solving the fishery problem would require considerably more knowledge than we have about fish population dynamics and considerably more attention than we have to date given it.

Because of pollution, overfishing and competition from exotics, several species may be out of the picture: the lake sturgeon and the deepwater ciscoes. The lake sturgeon, sometimes exceeding seven feet and 300 pounds, has been nearly exterminated. It does now receive limited protection under the Endangered and Threatened Species Act of 1973. In addition, the diversity of deepwater cisco (or chub) species that once inhabited the bay has now been essentially reduced to a single species, the bloater chub.

(2) Agriculture

Early agriculture in the region was characterized by wheat farming, followed by a trend to raising livestock. By the turn of the century, the Fox River Valley and the lower Wolf had become major cheese-producing areas. Those valleys have good agricultural soils that support vegetable production and corn. Poor soils of the northern areas of the basin make agriculture more difficult. There is now a trend toward reversion of this land to forest. The decline of farm acreage is probably a fairly permanent net loss of farmland. Farms are now, however, practicing a more intensive agriculture which depends heavily on fertilizers, pesticides and mechanization.

Agriculture in the watershed has a number of impacts on the bay itself. For example, as the number of cows per dairy herd increases, there is an increased concentration of animal wastes on the land. One tributary of the Fox River drains approximately 35,000 acres of primarily agricultural lands and receives an estimated phosphorus load of three pounds per acre in the spring. Rural runoff is the major phosphorus contributor to the Fox River during the spring. Most of it comes from animal waste washed off the frozen fields during a few weeks of spring rain and snowmelt.

A look at the landscape might indicate that erosion (and siltation) does not appear to be a major problem in the Green Bay basin. But even minor erosion in such a large watershed has a significant impact on the sediment sink area, that is, the bay. Thus, the rapid filling of the lower bay has occurred, as described earlier. The present soil conservation system treats erosion on a farm-by-farm basis and seldom tries to look at the regional scale. In addition, erosion control is intimately linked with land use control, a much contested issue. The solution to surface runoff does not appear to be waiting just around the corner.

(3) Forestry and Paper

By the late 1870s, the mouth of every log-producing river in the Green Bay region was lined with lumber and shingle mills. Oshkosh, with 24 mills on the banks of the Wolf, was "sawdust city." By 1890 pine stocks were down and mills were turning to hemlock. By 1920, Wisconsin was entering the era of the pulpwood log — spruce, fir and later, aspen, which was the dominant pulp species by 1950. While the contemporary thrust is pulp and paper, the demand for wooden products, such as hardwood molding, is increasing.

For the first time in modern times, there are shortages of various paper products. There are speculations that the rising prices will make expansion economically feasible for some mills for the first time in many years. Mill expansion on the Fox River, or other rivers of the watershed, could mean an increased waste load to the bay unless pollution controls are strictly enforced. Currently there is strict enforcement and it has had some dampening effect on expansion plans.

Growth in the paper industry could also mean increased demand for the pulpwoods that keep the mill going. Aspen now comprises at least 50 percent of the region's pulpwood. Within 30 years, aspen will be harvested to the hilt of its

allowable cut. Either pulpwood foresters must make the decision to maintain their aspen forests artificially through site treatment or the papermills will need to adapt to handling increasing amounts of other hardwood pulp.

In the nineteenth century, wholesale timber harvest of the watershed and the associate forest fires were followed by erosion. Some of the heavy sediments were trapped behind the numerous dams, but much went into the bay. That period also saw a decline in the natural recharge of the ground water table. The dams, built to help the water-borne movement of logs, restricted fish movement up the rivers. The impacts of lumbering, however, have declined since the decline of big lumber operations and the development of county forests with regular management.

But in the pulp and paper industry, environmental impacts are still a major problem. In 1967, 90 percent of the BOD loading entering the lower Fox came from industrial and manufacturing sources. Although there has been some noticeable progress and improvement in BOD loadings in the lower Fox, abatement is not progressing as rapidly as had been forecast. Continuing pollution of this type is significant, but enforcement and adherence to present standards could bring a major favorable change within the next decade.

(4) Recreation

Recreation is a multi-million-dollar business in the Green Bay region; in 1968, visitors to Door County alone spent over \$13 million. In spite of its overall importance, recreation tends to be a marginal industry which provides low individual income and has limited prospects for expansion. Accommodations continue to be heavily oriented toward the vacation trade and are almost entirely seasonal. Most are situated on or near a lake shore and feature fishing and swimming. But both the tourist and the recreation industry have to some extent turned their backs on Green Bay, concentrating on inland lakes and streams.

It is now clear that the turbid and often choppy waters along much of lower Green Bay's shoreline would not be first choice areas for swimming and beach activities even if pollution were reversed. Fishermen, however, are more tolerant of less-than-perfect water quality. Though Green Bay could accommodate many recreational boats, it is largely unused. Part of the reason appears to be a lack of access facilities and harbors of refuge.

The people of Green Bay have, over a period of years, become disenchanted with their bay. It appears that many of them see the bay as a boundary line rather than a resource.

It will be hard for Door County to experience more intensive recreation pressure and still retain its attractiveness. Ideally, some of the pressure should be transferred from the Door County side of the bay to the western side. It should be pointed out, however, that the land has a different character there, i.e., the wetlands. Given some relief from high water, the wetlands have a diversity of wildlife unmatched in most other areas of the state. If properly managed and promoted as a unique natural feature, the wetlands could become a major asset to the recreation industry.

(5) Shipping

Foreign ships and transoceanic vessels appeared in Green Bay in 1958 with the opening of the St. Lawrence Seaway. The initial spurt of traffic has declined, however, as freight companies have turned to container ships with a fast turn-around time and increased size. Midwestern ports, including Green Bay, are struggling with the issue of port modernization and how to keep their ship lanes free of ice in winter.

It is anticipated that interlake bulk transport of coal, iron ore, grain and stone could increase. But it does not appear that Green Bay will become congested with shipping. The trend is toward regional port development, and Green Bay will be hard-pressed to compete for dwindling general cargoes with larger, central ports like Milwaukee and Chicago.

The Future of Green Bay

From these observations of the past and present, we can make some predictions about where the bay may go in the future.

First, the bay's water quality could deteriorate at an accelerated rate due to continued pollution. This would occur because of a major shift away from present pollution abatement strategies. There is some pressure to roll back the required pollution control technology in industrial plants and additional pressure to put off the 1983 and 1985 goals of the Federal Water Pollution Control Act which call for zero or close to zero discharge.

Given this scenario, benthic organisms tolerant to pollution would continue to appear steadily up the length of the bay. Clams, snails and mayfly larvae (food for fishes) would disappear. Algae would increase in the lower bay with increased number of fish kills. Deposition of organic matter would increase, and this would reach into the middle bay. Oxygen depletion would increase in area and in duration. Recreational boating and fishing would decline. This general decline would work its way into Lake Michigan proper, particularly along the lake-side shore of Door County.

A second scenario would be a moderate cleanup of the Fox River Valley with curbing of gross municipal and industrial pollution. This involves primarily the removal of BOD loadings from the Fox River Valley.

Water quality in the Fox River and in the lower bay would improve "technically." That is, it would be better oxygenated, with less production of hydrogen sulfide. Pollutant-tolerant organisms would begin to retreat toward the mouth of the Fox River, with fewer fish kills. Fish, particularly yellow perch, would increase in number. Deposition rates might continue at their present pace, but would probably not increase.

Such a scenario would not deal with the "nonpoint" sources of pollution, particularly farmland runoff and storm sewer drainage. The lower bay would continue to be highly eutrophic and turbid. The water would be more technically cleaner than it is now, but would likely remain dirty in the people's minds.

A third possible scenario would be a program to systematically eliminate point and nonpoint source pollutants. This would include the control of storm sewer runoff and the inputs of farm fertilizers. Such control methods would greatly aid in reestablishing the bay as a recognized public resource.

At the present time, the second scenario of continued BOD removal and no control of dispersed pollutants appears to be the most likely course of action. However, economic conditions could change the rate of development of the region and could affect continued or future enforcement of pollution abatement.

A major intent of this report is to make recommendations on research needs in the Green Bay system based on a thorough study of the bay and its characteristics. Details of our research recommendations are in the final section in the longer report. In brief, we recommend more attention on:

- (1) The effect of the fluctuating water levels on pollution distribution, on the biological communities in the bay and on how the water level relates to shoreline development strategies.
- (2) The location, size, ownership and quality of wetlands bordering the bay and the relationship of the wetlands to the bay's productivity.
- (3) The effect of farmland runoff on eutrophication of the bay.
- (4) Size of fishing stock in the bay, the location of spawning grounds and the current food web as it influences fishing stocks.
- (5) Verification of physical conditions as predicted by the various models developed to describe the bay.
- (6) Sources and rates of sediment deposition in the bay, with additional attention to microcontaminants in these depositions.
- (7) Current status and distribution of microcontaminants in the bay, including heavy metals, pesticides and PCBs.
- (8) Analysis of the possibility of integrated coastal zone management.
- (9) Analysis of alternative economic futures for the region and the environmental impact of these alternatives.

A research program based on further involved inventories of isolated bay problems does not appear to be a fruitful endeavor at this time. It appears to us that an integrated research approach would be more productive than a categorical and specialized approach. Such an effort should deal, in a quantitative way, with the effects of specific resource use policies or pollution abatement strategies on water quality in the bay and Lake Michigan. Such an effort should also involve greater cooperation with the state of Michigan, the managers of the northern third of the bay. By drawing together knowledge of social and economic trends, resource management strategies and the bay's physical and biological systems, an integrated approach would hopefully weld these into an effective planning tool and develop the state-of-the-art in predicting change.

In the past, Green Bay has been a resource of great value to the people of Wisconsin. It could be so again, but only foresight and the desire of Wisconsin's citizens can make it so.