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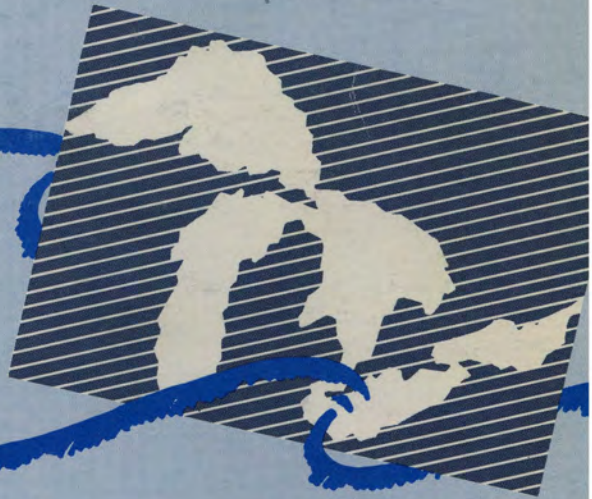
THE GAMUT

*A Journal of Ideas
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THE GAMUT

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THE GAMUT

Number 21
Summer 1987

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The North Coast?

For someone who was born on the sea, being able to find a horizon unobstructed by land is a constant necessity. I have always tried to live in cities on the coast and to vacation in places where the sea was easily reachable. Moving from New York to Cleveland nearly two decades ago was made easier by the knowledge that there was a large, if shallow, inland ocean just north of the city. My first apartment was downtown where I could see the lake from my window. The view was too constricted, however, so I found a place in a high-rise building within a short walk of the waves. For those who are from land-locked states the satisfaction to be derived from an occasional inspection of that ruler-straight line on the horizon may be a mystery. For me it was a tonic during the six years I spent in Bratenahl. And walking on the ice boulders in mid-winter was a special treat. I haven't lived there for ten years but it is the thing I miss most in my present location deep in Cleveland Heights.

To travelers going to Canada, the Great Lakes can be an obstacle that must be negotiated by finding the seam between them. To others they are an immense reservoir of fresh water, the largest quantity on the planet. To geologists, they are a remarkable geological curiosity. For the residents of the area they are a guarantee that they will be able to water their lawns during the driest summer and that they can, by going only a few miles, view a large expanse of water any time of day or night. And of course fishermen, boaters, and yachtsmen have their own reasons for appreciating the lakes.

Local publicity about the North Coast and its allure may seem to be about the same thing, but I doubt it—it is good hype but not good geography. The lakes have a variety of different coasts and are at different latitudes, but they are quite unlike the east or west coasts or the real north coast in Alaska. We lakesiders live not on the North Coast, but in the Great Lakes Basin, an enclosed complex of beaches, coves, depths, locks, and falls, utterly different from what is conveyed by the idea of a coast. Cities at the same latitude as Cleveland on both coasts are a long way from the northern boundary of the United States: from New York City, one must travel 550 miles before reaching Madawaska, Maine, across the St. John River from Edmunston, Canada, and on the west coast, the 42nd parallel is over 450 miles from Canada. So what is called our North Coast really sits almost east of the center of our land mass. We are rich with water, the envy of Arizonans and others and we should know a little about how this came about. Our emphasis this time will help you get the picture.

Louis J. Miles

The Bird's Nest:

Making of an Ethnic Urban Village

James and Susan Borchert

For most of us the phrase "urban village" brings to mind places like Rocky Balboa's Italian South Philly, with its densely settled, tightly packed buildings and small knots of residents conversing together along the sidewalks; thick smells of food and sweating bodies and the sounds of voices shouting in strange, vaguely romantic tongues flood our senses. These images may be stereotypes, yet most of us remember the pleasures of a day spent in one of these neighborhoods attending a wedding or religious festival. We marvel at residents' ability to preserve close personal contacts and to know everyone in the neighborhood. The built environment reflects this intimacy through the closeness of its buildings which seem to nudge and touch each other despite the diversity of their forms and uses. Such glimpses remind us of our heritage as a nation of immigrants; they also reveal a dynamic landscape seemingly long lost in contemporary America: a real, functioning village community in the midst of the city, combining the best of both worlds.

From the perspective of a suburban dweller raised in a detached, single-family home with 2.5 cars, an automobile drive away even from the local Seven-Eleven, it takes some effort fully to appreciate the vital and close-knit urban village in which practically everything one might need, from midwife to ethnic funeral home, all exist just a few steps from one's home. For many of us such urban villages are museum pieces, remnants of a vaguely remembered grandmother's tale.

Yet the notion that the urban village is irrelevant to modern society is far from accurate. As new immigrants from Asia and South and Central America flood our cities along with those from Europe and the rural U.S., new ethnic neighborhoods appear: Hasidic Jews in Williamsburg (Brooklyn), Vietnamese in downtown San Jose, and the Puerto Rican "barrio" in Lorain, Ohio, all demonstrate the continuing vitality of the urban village. Nor have all the older ethnic neighborhoods disappeared: while communities such as Cincinnati's "Over the Rhine" and New York's Jewish Hester Street have all but vanished, and Detroit's "Poletown" and Boston's Italian West End have suffered mightily from urban renewal's wrecking ball, many others remain. They not only tell us a great deal about the immigrant experience of the past—they also provide the best available working plans for effective neighborhood development.



"We believe a scholar should get as close to the subject as possible—Susan and I have lived in Birdtown for two years," says James Borchert. One of the Borcherts' most valuable research techniques was delivering telephone books. "This gave us access to every household with a phone and an opportunity to see firsthand how the interior of each tenement was organized." A native Clevelander, Borchert is an associate professor of history at Cleveland State University. Susan Borchert, whose Ph.D. is from Ohio State University, teaches social science at Lake Erie College. She has a long-standing interest in race and ethnic relations, social reform, and once taught a course on the recent changes in gender roles (sponsored by San Jose University) at Soledad Prison.

"The Bird's Nest" in Cleveland (also known as "Birdtown," or "the village") is one of these persisting urban villages. Despite signs of age, it remains, after ninety-five years, a live and adaptive community. Unlike many ethnic enclaves, Birdtown's original site in suburban Lakewood, just outside Cleveland's city limits, meant an opportunity to build from scratch. As a result it provides an excellent location to view the creation of an urban village and to "read" the emerging landscape.

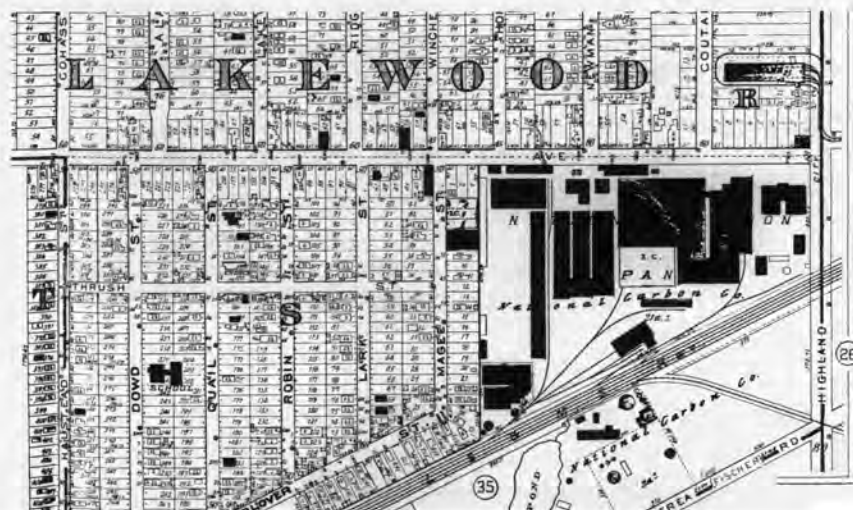
A rural village in the city

Like other ethnic urban villages Birdtown sits close by the factories where its first residents worked. A rail corridor to the south, and factories on the east and west isolate it from other residential areas. On the north a secondary commercial artery, Madison Avenue, provides a permeable boundary which immigrants eventually spilled across. South of Madison, the village consists of eight narrow, cul-de-sac streets (its nickname derives from the five streets named for birds: Lark, Robin, Quail, Thrush, and Plover).

An important part of Birdtown's "urban" texture comes from mixed land uses: homes, stores, and churches indiscriminately line the streets. In the early years residents kept gardens and raised geese and other domestic animals; such rural elements, along with several dairies in the neighborhood, produced a strong village atmosphere. Today the animals and dairies are gone, but the isolation, small scale, carefully tended front yards, and general ambience preserve a village character.

The village had much in common with other inner-city ethnic enclaves. From the beginning, "Hungarian Slovaks" and their children dominated its population (70% in 1910), although Americans of Polish, Carpatho-Rusyn, and Ukrainian descent comprised important minorities. As in other ethnic enclaves, many people jammed into the limited space. In 1920, when Birdtown reached its peak population, few Cleveland census tracts exceeded its density. Most Birdtowners walked to unskilled jobs at neighboring factories and received low pay for long hours of work; their homes, often cold water flats, lacked electricity, modern appliances and plumbing. These difficult living conditions helped account for relatively high disease and death rates.

The Bird's Nest, National Carbon Co., and the surrounding area as it appeared on a 1912 platbook. Most houses in 1912 clustered in the southern part of the neighborhood on and near Plover, the initial "central business district." A secondary cluster formed around Thrush, Quail and Robin as the neighborhood began to expand. G. M. Hopkins Co., Platbook of the City of Cleveland, Ohio and Suburbs, Plate 27. This map has been cropped; the southwest portion is also cut off.





1929 PHOTOGRAPH

FACTORY A and office building in 1929. (Union Carbide Corporation.)

“Bring in some good workers like yourselves”

In 1892, National Carbon Company (now Union Carbide Corporation) purchased land for a factory just to the west of Cleveland. On the eastern half of the land they planned an office and factory. Slavic workers came to this environment initially perhaps by accident; somehow a few Slovak immigrants gained unskilled construction jobs at the factory site. At the time the foremen who controlled employee recruitment generally acquired new laborers by asking their charges to “bring in some good workers like yourselves.” Those workers, in turn, brought in their relatives, friends, and neighbors who needed jobs. Slavs came to dominate the unskilled construction jobs. When the factory opened up, these workers and eventually their relatives, friends, and neighbors established control over the unskilled factory jobs.

With little housing near the factory and no completed streetcar line from the city, employees of National Carbon Company found it hard to get to work. Although they could take the streetcar part of the way, they had to walk several miles beyond the end of the line to reach the factory. Winter snow and mud throughout the year made the effort all the more arduous.

In response to these problems, National Carbon set up a subsidiary land company, Pleasant Hill Land Company, which subdivided the western half of their land holding into eight streets and 424 narrow lots. It is not clear if they planned to build a factory town, though in the early years PHLC did construct some houses and rent them to workers. But they soon sold these as well as the remaining unimproved lots; the last one sold in 1923.

The “village” adjacent to National Carbon grew slowly; by 1900 it had only 429 residents. During the next decade, however, the population grew dramatically to 2,186, and between 1910 and 1920 it doubled again. A construction boom just before World War I filled many of the lots; additional building between the Great War and Great Depression completed the neighborhood save for the few post-World War II ranch-style homes that now dot the neighborhood.

It is not surprising that Slavs, having gained a strong foothold in construction work, then unskilled factory jobs, ultimately came to dominate the neighborhood. But it was not easy. Despite the advantage of living near the factory, low wages and long hours gave workers few resources with which to buy a house and lot. Birdtowners overcame the obstacles by helping one another: relatives, friends, and neighbors pooled skills and financial and social resources to make it possible ultimately to construct a neighborhood.

Building the nest

Early on, perhaps as early as 1902, they formed a building association; in 1911, the state of Ohio chartered Orol (Eagle) Savings and Loan Company (now Home Federal Savings and Loan). Through this institution villagers could speed neighborhood acquisition and building. In addition, many lot owners invested "sweat equity" by building their own homes. Neighbors, friends, and relatives often helped. Those who hired builders most often paid neighbors to do the work. In either case, villagers aided one another and kept resources within the community.

In the first years only a few could afford to buy or build their own homes and those who did found themselves hard pressed to meet their obligations. Villagers adopted a solution common in new urban villages: the boarding house. This institution came to play a key role during the years of settlement. In 1910, on the eve of the village's major construction boom, one-third of Birdtown households took in boarders, while boarders themselves made up one quarter of the population. Boarding worked because it provided workers with inexpensive places to live at the same time that it gave financially pressed home owners extra income. A future home owner could rent a house and use boarders' rent to pay the owner and raise a downpayment on his own home, while a boarder could save money to send to relatives or to begin his nest egg.

Boarding also served important social purposes. Families who kept boarding houses often "adopted" the boarders—most of them young men, recent immigrants. In the process unattached immigrant workers gained the benefits of a family setting and avoided isolation. Moreover, these links with families provided them with access to the emerging social life of the community.

Initially, young men migrated to the neighborhood to be close to their work and to save money. Eventually, as they formed their own families or sent for their wives in Europe, Birdtown builders contrived a new architectural form especially well adapted to the needs of small, young families with limited resources. The narrow lots and high initial construction costs made large-scale apartment buildings unfeasible. Instead village craftsmen produced a tenement that looks like a double house and reflects some aspects of Slovak folk housing. But, although typical "Cleveland doubles" have one family per floor and entrances and porches in front, many Bird town structures housed as many as six or eight families in separate units. The real entrances were on the side, where two sets of stairs provided access to two small apartments per floor. With side bulk largely hidden by the closeness of adjacent buildings, these structures fit well and maintain the village scale.

Like boarding houses, this layout served well the needs of the emerging neighborhood. With so many newcomers the village could have suffered greatly from dislocation. Unlike many apartment buildings where long, central, double-loaded corridors made interaction difficult, the "sixes" and "eights" provided a human scale where each corridor of four units made up a tiny neighborhood. Even the few Birdtown apartment structures adopted this pattern of side entrances and four



Orol Federal Savings and Loan Association, 12223 Madison Avenue, ca. 1930. Courtesy of Home Federal Savings Bank.

Typical Cleveland Double that is in fact a tenement (1986). Notice the side entrance that provides access to most units in the building. Multiple electric meters on the side of the house suggest the number of different units in the building.



units per stairwell. An inner court gave neighbors of both buildings a shared commons, a village within a village removed from street disruptions.

Other residential structures were also adapted to the neighborhood's needs. Some Birdtowners used a strategy common to other migrant neighborhoods in midwestern industrial cities: front and back houses on the same lot. Owners lived in one house and rented the other. As with boarding houses and tenements, this practice eased owners' mortgage payments and increased the supply of rental houses. The proximity of front and back single-family houses conformed to the village pattern of linking a few close neighbors.

As families grew larger and more affluent and as more relatives left Europe to join extended families in the village, double houses and single-family, detached houses claimed the remaining vacant lots. In any case, village property owners did not view their homes as having permanent form. They added rooms when they needed more space. As the neighborhood became more affluent, owners installed electricity and full plumbing. More recently, as housing demand declined and the desire for larger apartments grew, owners collapsed the "sixes" and "eights" into fewer units. Through it all, residential structures remained organic as villagers adapted them to current needs.

While each individual home builder decided issues of house site and facade, the collective result reflected villagers' concerns about their new community. Working within such constraints as narrow streets and a lot size determined by PHLC, Birdtowners chose to locate their homes close to the street. This arrangement produced a close, tightly knit physical structure with street-facing homes only narrowly divided by small front yards. Villagers moved even closer to their neighbors by adding front porches. As porches and front yards became regular meeting places for friends and neighbors, the distinction between public and private space broke down and residents merged in a robust street life. Isolation from the rest of the city and cul-de-sac streets discouraged the disruptive presence of outsiders and further focused neighborhood interaction within the village.

Ultimately, then, Birdtowners constructed a residential environment, both social and physical, that linked villagers together and encouraged their constant interaction; it plunged every resident into an overlapping series of informal groups ranging from boarding and tenement mates to street-facing neighbors. Obviously, "neighboring" is important for any new community. These interactions, however, involved much more than might immediately seem apparent. First, in a community with limited resources, where residents depended on each other for help locating employment, housing, and with home construction, constant interaction helped individual and collective survival and success. Moreover, as neighbors gossiped daily about each other's behavior, they began to construct a sense of what was acceptable and unacceptable behavior for the community. While never formalized and always changing, this gossip-based etiquette codified the village's world view.

Through it Birdtowners judged each other, weighed important decisions both personal and collective, and interpreted larger events. Ultimately, it helped produce a Birdtown identity and an *esprit de corps* out of the diversity of religious, ethnic, and class backgrounds. Finally, these seemingly simple daily interactions laid the base for the larger organizations—the churches, schools, lodges, and businesses that we often take to be the neighborhood itself.

Forming the institutions

Initially the first villagers commuted to the parish where they had previously lived to attend church services. When this proved too difficult they held informal prayer meetings in the home of a co-religionist. Such meetings led to the formation of a lodge; members of each denomination set out to raise money to build a neighborhood church. Despite limited resources, small population and an even smaller number of congregants in each group, they soon succeeded: by 1905, villagers had founded four core churches, and by 1906 all had constructed their first buildings. Ultimately eight churches formed in the immediate neighborhood in addition to several outside the area.

Religious institutions mirrored the neighborhood's religious and ethnic diversity. Slovaks founded three Lutheran, one Roman Catholic, and a Calvinist Presbyterian church; with Carpatho-Rusyn and Ukrainian neighbors, they organized three Orthodox churches, while Poles started their own Roman Catholic parish.

As churches grew, informal neighborhood groupings began to tighten along denominational lines; the extensive religious, organizational and social activities of each church focused members' interactions on each other as it restricted those with members of other churches. Villagers came to identify Birdtown in terms of their own institutions; as one long-time member of Sts. Cyril and Methodius recently recalled, "it was just like a little village, and the pillar was St. Cyril."

By establishing their own churches, villagers exercised considerable control over their direction. Although immigrants sought freedom and economic opportunity in the New World, they did not intend to reject their past. Initially, many sought to maintain traditional institutions, values and ways of life; the founding of churches reflected this concern as did the continued use of native languages and education programs on ethnic history and culture. At Sts. Peter and Paul Lutheran Church, Slovak served as the exclusive language for services until World War II, and even now most churches continue to have at least one service in the native language of its founders.

Churches visually dominate the area and provide much of its distinctiveness. Over the years parishioners made incredible sacrifices to raise funds sufficient to erect the large, impressive



Interior of SS. Cyril and Methodius Church. Photograph courtesy of SS. Cyril and Methodius Church.

church buildings that line either Madison or Quail; the choice of brick or stone building materials in all but the smallest church clearly underlines their concerns for permanence. In contrast to the highly plastic and utilitarian residential landscape, these handsome and monumental church facades introduce a visual splendor and monumentality, while inside, the impressive, finely decorated sanctuaries provide the neighborhood's only large interior spaces. Nevertheless, by constructing their churches close to the street villagers preserved the neighborhood scale and reduced the appearance of monumentality.

Religion permeated the neighborhood in other ways. Although the city of Lakewood built Harrison school in the neighborhood, both Sts. Cyril and Methodius (1905-present) and St. Hedwig's (1926-68), established their own primary schools. In the early years St. Cyril's required courses in Slovak language, history, and culture. The first American-born generation benefitted from these experiences but they also began to translate and adapt traditional culture to fit the new environment. At the same time they began to adapt elements from "American" culture to fit their needs. Rather than abandon Old World traditions, Birdtowners created a blend of Euro-American culture that conformed to the village world view.

Locally owned businesses also played a key role in the neighborhood. Unlike the churches, which quickly located on Madison at the neighborhood's edge, many of the first businesses located on Plover, the most isolated and interior street; this was also the site of the first home construction. In some respects this location reflected Birdtown's isolation, inward orientation, and self-reliance. Later, as the neighborhood grew and spilled across Madison Avenue, as some enterprises became more successful, and as villagers themselves grew more prosperous and confident, the business center shifted to Madison.

If Plover and later Madison served as the "central business district," many smaller businesses located throughout the neighborhood. To supplement income, many Birdtowners ran tiny shops, stores, taverns or processing plants out of their homes; garages and sheds housed dairies and other enterprises. Front yards also played a part in this burst of entrepreneurial spirit; villagers constructed small rooms in front of their homes to house taverns, grocery stores, and other retail activities. Both mixed land use and mixed architectural form added significantly to Birdtown's distinctive urban ambience.

As they did in the boarding houses, women played a crucial role in these small businesses, since husbands and many older sons and daughters were working at neighborhood factories. The fledgling stores and shops provided both additional family income and important neighborhood meeting places, especially in bad weather. By supporting local merchants Birdtowners gained the benefits of locally owned business, kept



Class of 1920, SS. Cyril and Methodius School. Photograph courtesy of SS. Cyril and Methodius Church.



Housefront tavern (1986).

money within the community, and approached self-sufficiency. Thus economic advancement derived from neighbors' support of one another, as was the case in finding jobs and housing.

It is a comment both on the times and the nature of the neighborhood itself that in 1930 it could support over 120 businesses. There were twenty-five grocers (including four chain stores), seventeen bakers and confectioners, and eighteen retail establishments. Although prohibition made bars illegal, some enterprising bootleggers, according to oral history, maintained an active trade; and at least one midwife and three undertaking establishments also served the neighborhood. Billiard parlors, bowling alleys, dance halls, a gym, and a motion picture theater supplemented the church activities.

Clearly many of these institutions brought the blessings of American popular culture to Birdtown; villagers also could experience the host culture through both suburban and downtown institutions. Despite its initial inward focus and physical isolation, Birdtowners never sought to shut out the larger society nor were they overly cut off from it.

This did not mean that villagers abandoned their own cultures for "American" culture as is often implied by the "melting pot" myths. The persistence of the urban village's rich institutional life demonstrated the strength of religious and ethnic ties. In reality, the urban village provided a buffer between the larger society and the immigrant community. Birdtowners confronted America in the context of their own community and, through personal and institutional networks, they collectively created their own version of American culture. The important point is not that immigrants and their children resisted adopting the host culture, although each generation of villagers viewed this issue differently. Rather they selectively borrowed those aspects that seemed most appropriate and carefully integrated them into their own practices. This result multiplied by urban villages throughout the U.S. produced the incredibly complex and diverse society that we now have.

The old neighborhood changes—a little

Much has changed in the ninety-five years since the Birdtown's founding. But the village continues to function despite both economic stagnation and a substantial movement out of the area. What stands out are neighbors' collective efforts to confront change through village institutions, and to adapt to new conditions. Even those who have left have often continued their involvement in the neighborhood or joined with other Birdtowners to found "new" institutions elsewhere.

The post-World-War-II period witnessed the greatest change. Increasingly villagers used "native" languages less; while Slovak continues to be spoken in most neighborhood institutions, few third or fourth generation children can join in these conversations. Villagers adapted traditional customs and cuisine to fit changed needs and merged them with "American" practices. If the first American-born generation tended to

marry within both the ethnic and religious background of their parents, succeeding generations have strayed more frequently beyond ethnicity if not religion.

Through hard work, multiple jobs, and business enterprise, villagers have earned considerable success. Although few first-generation families moved up out of their unskilled jobs, many did succeed in buying their own homes, an effort that required considerable sacrifice by the whole family. The second generation, American-educated, drew on their parents' access to unskilled industrial jobs first to gain employment and then to gain promotions to more skilled and better paying work. By 1940, the success of these intergenerational efforts became clear; most American-born villagers worked at skilled or semi-skilled positions and 13% held white collar jobs.

In the last twenty years, as older factories have laid off workers, closed down, or moved out of the area, the third generation has found it increasingly difficult to take advantage of the old beachhead in industrial jobs. While some grandchildren continue to work for the same employer as their parents and grandparents, most have to go outside the neighborhood for employment; during this period for the first time more villagers have commuted by car than walked to work.

Increasingly, younger generations of villagers have chosen to move out of the village. Early on, Birdtowners had spilled over Madison, spreading north and west across Lakewood, and eventually this migration led to more distant suburbs. Residents moved for a variety of reasons. Some undoubtedly found the tight village *gemeinschaft* suffocating, while others sought newer, more modern housing. Eventually the decline of local employment opportunities encouraged migration out of the county and even the state of Ohio.

These distant moves did not necessarily reflect either a rejection or abandonment of the neighborhood. Many former villagers continued to own neighborhood property; many returned weekly for church services and to visit friends, family, and other institutions. Moreover, as many of the first villagers came to the neighborhood as part of a chain migration, so too did the neighborhood spawn its own chain migration of residents to more distant suburbs. Again, neighborhood institutions played a role in this process; at least one village church reproduced by fission when a group of its members moved to Parma, Ohio, and founded their own church there. Although they left the village, they did so in the context of other villagers and of a village institution.

Local business declined sharply in the post-war years as affluence reduced the need for supplemental income, and chain stores increasingly cut into profits. Bars and taverns appeared most resistant to these changes, but the number even of these has diminished in recent years. Not surprisingly, the many small grocery stores and confectioners have also declined precipitously. Even the chain stores pulled out of the community as marketing underwent major changes in response to the automobile. Housefront shops along residential streets often were the first to go; residents simply integrated these small rooms into their homes for more space. Larger mom-and-pop groceries continued to hold out for some time.



The U-NO Motion Picture Theater, 12224 Madison Avenue, ca. 1930. Photograph courtesy of Amelia Bendik Cotter.

Still a number of key institutions remain, including several funeral homes and the Home Federal bank. And two new projects represent important additions: a new community center and a major senior citizen housing facility. The latter permits elderly residents to remain in or return to the community. Recent renovations to several churches demonstrate the continuing vitality and willingness to re-invest in the neighborhood.

Perhaps the greatest tribute to the initial village pioneers is the persistence of the village and its institutions. For long-time residents the neighborhood still functions well, and it continues to attract even former residents. The village churches flourish, and they draw a steady flow of visitors who are attracted both by their beauty and the quaintness of the neighborhood. The utilitarian commercial and residential landscapes continue to demonstrate their adaptability to changed needs and times.

It is important to note the role of the village itself in this success story. By pooling their resources and helping each other, Birdtowners not only constructed a viable community; they also made it possible for each generation to build on the successes of the previous ones. Ironically, these successes ultimately led to the loss of many who helped build and maintain the neighborhood.

What emerges from this story, then, is the collective struggle of immigrants and their children to succeed in the New World. To do so they created dense, tight villages that protected them from the abuses of the larger society and gave them some control over their own lives. Through the village they confronted America; from this interaction villagers created institutions and a viable culture drawn from both the Old and the New Worlds. Like newcomers throughout the United States, Birdtowners developed their own versions of American culture and experience and by so doing added to the richness and diversity of America.

The urban village stands today as a monument to migrant skills and abilities at neighborhood and community development. Few twentieth-century architects, planners, or developers have worked with such limited resources or had such success; few have understood so well the qualities of urban living or have so successfully integrated the elements of human scale, neighborhood interaction, and a functional mix of activities. In such neighborhoods, immigrants managed to combine the charm of Old World villages with the practicality and inventiveness of the New. ■

Recommended Readings

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FICTION

The Mortal Cauliflower

Ethna Carroll

For lunch they had cauliflower with jacketed potatoes and lamb chops. Their mother lifted out the steaming head of fluffy white cauliflower and cut it into five uneven pieces and dished out a piece each to Rebecca, Fiona, and herself. There was nothing tastier to Fiona than hot steaming cauliflower with a knob of butter and pepper and salt, except the hot floury potatoes themselves, and so halfway through her piece, she said that she would have one of the other pieces as well.

"Hold your horses," her mother said, "you haven't finished the one on your plate."

When she was finished chewing the last mouthful of cauliflower she said, "I'll have it now . . . no, not that one," when her mother began to lift the smaller piece, "that one," touching the larger one with the tip of her knife.

"Greedy thing," Rebecca said.

"That's a bit on the big side for you all right," her mother said.

"No, it's not. I'll be able for it. I will."

Fiona finished her potatoes first, her glass of milk and lamb chop, and then proceeded to her cauliflower. Halfway through, she put her knife and fork down slowly and said haltingly, "I'm a bit full all right."

"Eat the rest of that now after making such a fuss about it," her mother said.

She ploughed through a few more bites before saying, "I can't."

"Eyes too big for your belly," Rebecca said in disgust.

"They are not. Tell her . . ."

"Eat that now after insisting on having it and depriving the rest of us out of it."

If there was anything Fiona hated, it was people saying things like eyes too big for your belly or you'll be crying on the other side of your face when she was roaring laughing and having the best time of her life. Comments like that succeeded in putting dampers on everything and in turning her mood for the worse. Then she would feel so angry she could cry, and then the person who said it had won over her and would say "I told you so." Now she sat looking at this cauliflower unable to eat it, because anger had put the final quench to the little appetite she had left.



Despite her Irish brogue, Ethna Carroll's first words were spoken in Malay. She was born in Singapore and spent her summers as a teenager visiting her father in North Borneo. Educated by the Dominicans in Ireland, she took a three-year Montessori teacher training course, and subsequently worked as a preschool and kindergarten teacher. Currently she is a graduate student in English at Cleveland State University. She became interested in writing short stories by thinking back on life in Ireland and making it the setting of her stories. "I discovered that writing was a real antidote to homesickness."

"I can't eat it."

"You have to eat that now," her mother said.

"Well, I can't eat it with you all looking at me waiting for me to eat it. I can't eat it like that."

She sat staring at the translucent stalks of the cauliflower. She lifted her head and said:

"Can I bring it into the dining room and eat it away from all of you?"

"All right," her mother said, "I don't care where you bring it so long as it's eaten."

She took her plate and went into the dining room. The cool of the dining room was pleasant after the steamy kitchen. The sun had left the room where it shone in the mornings, and she could see it now shining on the grass beyond the plum tree, which stood in the center of the lawn in front of the dining room. The half-drawn curtains created a calming light. She didn't know what she would do with her cauliflower. She just knew she couldn't eat it, but at least in here alone she had peace as well as her problem. She could hear Rebecca and her mother talking in the kitchen, probably giving out about her. Rebecca was saying all dreadful things. "She's a spoilt brat," she would say. Never would she leave this room unless it was minus cauliflower. She pushed her plate away from her and laid her cheek down against the cool shiny surface of the table. To the right of her, she could see chess trophies her father had brought home with him the last time he visited them and the silver stand with the plates in three tiers, letters and cards on the top plate. Beside the window the sewing machine sat on its little table, an empty box of Black Magic chocolates held buttons, an empty tin of biscuits with a cocker spaniel on the lid held other knick-knacks. Then all of a sudden she knew what she would do. She jumped up from her chair and ran over to the cocker spaniel tin, emptied out the zippers and spools of thread that she found in it into the Black Magic box. She ran back to her plate, lifted the cauliflower in her hands and dumped it in the tin, closed it and put it behind the sideboard. She sat back at the table, smiling at her solitary lamb chop bone, breathing out a deep breath.

After a few more minutes, she got up and went back into the kitchen putting on her previous more sulky self as she said, "There," sliding her plate onto the kitchen table with downcast head and pouting lips. "That's very good now," her mother said, sounding both surprised and relieved. She said it again as Fiona took up her school bag to return to school, "That's a very good girl," she said as Fiona walked down the hall.

A week later Fiona stood with Rebecca mixing cocoa, sugar and a little milk together in their cups waiting for the kettle to boil. Their mother sat at the kitchen table. She stared out before her with a dazed expression she always had in the mornings. "What is it, eh?" she said as she put a bit of butter on her toast and then absent-mindedly put a bit of Old Time

Irish marmalade over that. "What is life, eh?" When she finished her cocoa, Fiona pulled at her mother's arm asking if she could take threepence from her purse. "Here," her mother said handing her the bag. She found a threepenny piece and went off down the road to school. By the time they got back at lunch, their mother would be more like other people's mothers with apple tarts coming out of the oven and a hot lunch made.

After calling for her best friend, Emer, they walked past Hayden's sweet shop which was still closed. Walking by the crossroads Emer changed the conversation they were having when she said, "Wouldn't it be great to be sick?"

"Yeah, but not sick in your stomach, because then you wouldn't be able to eat all the sweets everybody brought you."

"And then everybody would bring us coloring books and crayons."

"And say if a car came along now and bumped the two of us."

"Just a little bump that wouldn't hurt."

"And the two of us broke our legs, and we'd sit up in hospital together."

"Yeah."

And they continued talking past Mac's newsagents and down to Menton's shop. They went into Mr. Menton and bought a halfpenny's worth of cough drops. Mr. Menton was a white-haired man with a squint in one eye that sometimes made Emer laugh, and he sold them cough drops by the halfpenny even though they were usually sold by the quarter pound. They just chanced asking him for a halfpenny's worth one day and he'd said yes. When they reached Furlong's, Mrs. Furlong was fixing the fruit along the counter and her son, John, was waiting for customers. They decided to check out their favorite story in this week's *Bunty*, "Lettuce the Greenest Girl in School." They both loved that story and were laughing at Lettuce's round glasses slipping down her nose when Mrs. Furlong said, "Now girls, if you're not buying anything." When they walked out the door they could see "The Nook" across the road. "Hello, Mr. Nook," they said going in the door. Mr. Nook was a quiet man with a fat bustling wife behind the counter, and he let them have free ice pops if they could find damaged ones in his freezer. He said they could look in the freezer today, and they stayed eating their ice pops in the coziness of his shop looking at the games and toys displayed in the enclosed glass shelves beneath the counter.

Coming out of the Nook they rounded the corner by the drapery store onto the seafront. Emer's ringlets blew beneath her white bows against the sea breeze and Fiona's fringe blew back off her forehead, though her plaits stayed steady down her back. In the distance, across the bay, they could see the most even peak of the Dublin mountains, the Sugarloaf, the sun shining on its top today. They walked in the gate that led to Saint John's church, where on the far side they could see the wall with its small brown wooden door that led into the

school grounds. On the church side of this wall hung a huge crucifix with a loose nail that could be taken out of Christ's feet. Fiona had taken that out when she was very small, before she had even started school. She had lifted out the nail while her mother watched and waited for her. "Put it in now," her mother said.

"But it hurts."

"It belongs to the statue. Put it back in."

"I don't want to," she had said. But she had to. She had put in the large black rectangular-shaped nail. Then she had kissed Jesus's cool toe. Beautifully cold from the sea breeze. Then she had turned to her mother. "I'll tickle Jesus's feet so he won't be crying," and she had proceeded to tickle the stone.

"Come on now, Fiona, we have to go."

"Did this little piggy eat roast beef?" she said holding Jesus's middle toe.

"Will you leave Jesus's toes alone," her mother said hauling her away by the arm, "The shops will be closed with you."

Fiona and Emer walked in and out of the hedging in front of the railing beside the cross. It was kind of like a maze and Emer said, "We'll play chasing her on the way home." "Yeah, because we might be late now."

When they opened the brown door all was quiet in the school grounds. Looking up the steps that led to the school door Emer said, "Say the door was locked and we couldn't get in."

"Yeah, and then we'd have to go home and say we were locked out."

"And then we'd say we forgot the back door was there."

"Yeah."

And then they opened the door to school. The creamy marble floor was divided from the brown border by a gold line. A pattern throughout the marble looked as though someone spilled a box of matches and the pieces scattered over the floor in a haphazard way. The sound of talking came from the classrooms, they weren't late. Entering the cloakroom Fidelma Nolan was saying to Elsie Kelly, "No, that's fast days not days of abstinence." "We didn't have that one for today," Fiona said. "Oh we did so," they said. "Did you do it Emer?" She had done it with her mother the night before. Fiona quickly changed into her indoor shoes and took out her catechism walking into class. Later that morning she got two slaps on the right hand and three on the left, the extra one for pulling away and making sister hit air. She saw Emer laugh through her tears. "Judas Iscariot," she said to her when she got back to her desk. "I couldn't help it, it's just your mouth looked really funny when you started to cry, it went into a really funny shape." "Then I'm going to laugh at you when you get hit." "I'm sorry, I'm sorry," she said.

But then sister gave out to everybody for shouting up "Grave matter, full knowledge, and full consent," in answer to

her question. There was no reason for any more of that brassy boldness they insisted on showing, she said. Then the story part of the day started and Fiona sat back comfortably and listened to sister say that no amount of venial sins would ever make a mortal sin. There were no sides to your soul and that meant that the venial sins could never be pushed into one mortal clump. Venial sins and mortal sins could be the same. To take a half crown from a poor man who only had one half crown would be a mortal sin, but to take the same half crown from a rich man would be a venial sin, because he had other half crowns. There was a poor man who walked down Vernon Avenue some days with a club foot and a grumpy unshaven face. He held his club foot with a walking stick and went along limping. If he had a half crown in his pocket he could buy thirty penny bars or thirty ice pops, or he could buy five sixpenny bars of chocolate. He could get four bonbons for a halfpenny, how many would that be? He could get six aniseed balls for a halfpenny, how many could he buy? He could buy loads. He could even buy thirty pink marshmallow mice with little black eyes, and then he would have to see if he would start at the head or the tail. Emer nudged her. There was silence in the room. People seemed to be waiting for an answer. She stood up. "What is God?" sister said. "God is our father in heaven." "Out by the wall." Fidelma Nolan was able to tell everybody that Fiona had told them all the answer to "Who is God?" Sister said that if people like Fiona Rafferty, in less than a year, thought they could stand before the archbishop of Dublin himself and tell him who is God when he asked what is God and persisted in telling him days of abstinence for fast days, when children a few doors down from the very room they were all sitting in, children that had barely attained the age of reason knew the answer to those questions, well, she said, if Fiona thought that she had another thing coming to her.

At lunch time Fiona's mother mashed the potatoes, "And did you cry?" That was the worst thing she could have done, her mother said. "I don't know what to do," she said pausing over the potatoes, "I just know we all have to go through it." Slicing the rhubarb tart later she said, "Persecuted, persecuted. It was the same for myself." And then she explained how Mercy nuns were noted for their lack of it. It was one of the insolubles of this world. "And then Elsie Kelly was thumped, because she said their baby tore out her multiplication sums from her copy book, and sister said the baby did no such thing and that Elsie Kelly was a barefaced liar." "Poor Elsie Kelly," Rebecca said. Their mother laughed, "I can't keep up with Elsie Kelly. Is that child never out of trouble either?" Lunch continued, and the conversation between them all was like a comforting cocoon in comparison to school.

It may have been an imperfect cocoon, but still it existed. But on the way home from school even that threatened to unravel. Just as Fiona was walking past Sunnyside estate with Emer, before she left Emer to turn up to Blackheath Avenue,

she stopped in her tracks. "The cauliflower," she thought in panic, "the cauliflower." It had vanished from her thoughts as it vanished behind that sideboard. "What's wrong?" Emer said. "Nothing, I've got to go," she said running off up the road. What would happen if her mother had let a letter fall down behind the sideboard and reached in to get it. Then what would happen to her? The front door pushed in as she fell against it. Her mother had left the latch off. The house was quiet. Her mother was up having a rest. She ran into the dining room and reached for the tin. It was still there. She opened the box but dropped it, for there was green mould growing over the cauliflower. She waited for any other sound in the house. There was none. Quickly she opened the dining room door and ran over to the wild-rose bushes and scooped out a pile of the soft clay with her hands. She overturned the tin and plopped the cauliflower into the hole, then got up and kicked the clay in over it. It was gone. Still, no sounds in the house. Rebecca would not be home on her bike for another fifteen minutes. She ran into the kitchen and washed out the tin, dried it with the tea towel and put the zippers and spools of thread back in.

That evening at tea time Fiona was talking and laughing animatedly when Rebecca interrupted, "What are you so happy about?" "Can't I be happy if I want?" she asked her mother. Her mother said she had no objection to that. ■



The Great Lakes

Lake Shores In Retreat

Michael J. Tevesz and
Samuel M. Savin

To geologists in northeastern Ohio, news about lake shore erosion is as sure a harbinger of spring as the robins, crocuses, and chuck holes that appear in early March.

The television news showed, as it had a year earlier, a rough and gloomy lake, frantic and frustrated property owners, a reporter, and an academic geologist. Each played his part. The property owners sounded scared and confused, the geologist sounded knowledgeable, and the reporter sounded competent. That is, he had absorbed all the information the geologist had given him before the cameras and microphones were turned on. And the lake roared away as if on cue.

Geological disasters—earthquakes, erupting volcanoes, floods, and landslides all make news: they are violent events that affect people's lives and property, and the aftermath of their activity produces dramatic images. Northeastern Ohio has a share of this geological action: frequent floods, an occasional landslide, a rare earthquake. But to a geologist, Lake Erie shore erosion is the most interesting kind of geological disaster that northeastern Ohio has to offer. It is Ohio's modest version of California's San Andreas fault. The "Battle of Lake Erie" is fought by countless shoreline property owners. Typical stories:

- A man in Bay Village went out to mow his back yard which was perched on a bluff above the lake. As he was r , the bluff, undercut by waves, gave way. He fell into the d was killed.
- A widow in Willoughby has been fighting the lake for years, and is slowly and excruciatingly losing. When she and her late husband bought a house and lakefront lot, the property had a beach. Within a few years, the beach had vanished and the garage was threatened. Not long after the garage was torn down, the waves from a big storm washed away its foundation. When the lake threatened the house they moved it to the far end of their property. Now, having exhausted her funds on these unsuccessful moves, the widow's last resource is the willingness of dump truck drivers to donate dirt and broken concrete to pile along the shoreline.



Michael Tevesz and Samuel Savin are currently producing a series of documentary videotapes on the geological history and natural resources of northern Ohio. Three (on Lake Erie history, water resources and shore erosion) are complete, and several more are planned. Tevesz (above), department chairman and professor of geological science at Cleveland State University, received his B.A. from Case Western Reserve University and his Ph.D. from Yale University. He has over thirty scientific publications to his credit.

- In one lakeshore suburb east of Cleveland the city government helps out homeowners whose houses are about to fall into the lake by permitting them to donate their property to the city. The expense of razing the doomed property is borne by the city, and the property owner gets the benefit of claiming his donation as income tax deduction.

Those who live around the lake keep hearing the same questions: "What is happening to the shoreline?" "Why are so many beaches vanishing?" "Why do we read about houses falling into the lake?" "Is the Corps of Engineers really conspiring with shipping interests to keep the water in Lake Erie high, to the detriment of beachfront property owners?" "Are we seeing the result of a sudden change of climate?"

Although the questions appear simple, they do not have simple answers, a circumstance that frustrates television reporters, who live on quick answers.¹ The changes that have occurred to the shoreline of Lake Erie are, for the most part, the result of natural processes acting now as they have for thousands of years. While people have tinkered with the shoreline system and altered it a little, both the natural processes and the human perturbations can only be understood in the light of some elementary geological principles. Citizens and legislators attempting to influence public policy concerning water levels, shoreline land use, and government assistance to property owners should be acquainted with these principles.

The Shore System in Northeastern Ohio

First of all, shore erosion is just one process of many operating on the Lake Erie shoreline.

The most fundamental scientific concept relating to this problem is that the shore, even when it appears stable and unchanging, is dynamic, much like a river that looks the same from day to day even though its water is constantly being replaced. All shorelines are products of gravity, wind, water, and ice, the same agents that shape most other features of our landscape. These agents act continually, so the shoreline is always changing.

The basin of Lake Erie, as well as those of the other Great Lakes, was gouged out of the landscape by the great ice sheets that covered the region numerous times during the past million years. Over fourteen thousand years ago, a glacier perhaps more than a mile thick covered all of northern Ohio. Alternately advancing and retreating, it created and altered bodies of standing water that were the progenitors of modern Lake Erie. The final retreat of the glacier permitted water to flow northeastward across the Niagara escarpment and over Niagara Falls, thereby establishing the Lake Erie basin, drainage, and the shore system. This shore system was formed and has evolved as the result of natural modifications and interactions of its three major subsystems, each influenced by glacial activity. These subsystems are the water in the lake with its



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waves and currents, the beaches and the sediments lining the lake bottom, and the bluffs behind the beaches. Each is distinct, yet all are interrelated. In understanding them, we can understand the operation of the whole system and its most interesting result, shore erosion.

Waves and Currents

When the wind blows across the water, its surface becomes disturbed. First ripples form. As the wind blows harder, or for a longer time, or over a greater distance or "fetch," the ripples grow into small waves that grow into bigger and bigger ones. The features of a wave that are most important in determining its effect on the shore are its height (the vertical distance between the crest of a wave and its trough) and its wavelength (the distance between successive crests). In open water, waves often appear to move steadily in one direction, which gives the illusion that large volumes of water are being transported in the same direction. Actually, any object floating in open water bobs up and down as wave crests and troughs lift and drop it, but it is not carried very far horizontally. Closer examination shows that the waves and the water move somewhat independently of each other.

When a wave moves through open water, in addition to its obvious effects on the water surface, it imparts circular motion to the water downward to a depth of about one-half the wavelength. This vertical component of wave energy has important implications for the shore system. As long as a wave is in deep water, its motion is not felt at the bottom of the lake, and it is unable to affect the sediment. But as a wave approaches shallow water it begins to "feel" the bottom. Then the wave is slowed down by friction with the bottom. The shallower the water, the more it is slowed. In addition, the wave begins to stir up the sediment. Then, two things happen. The sloping bottom pushes the wave upward as the beach is approached, and the part of the wave closest to the bottom is slowed more than the upper portion of the wave, so that the wave finally topples forward and breaks, producing surf. Because the wave collapses forward, it takes on a significant horizontal motion that it lacks in open, deep water and as a result, sweeps onto, and sometimes across the beach as swash. Gravity then returns the water down the beach slope as backwash into the lake.

Because of the interaction between waves and bottom sediments, the geometry of the lake bottom is important in determining the way in which waves will affect the shore. For example, a wide stretch of shallow water in front of a beach tends to dissipate wave energy through friction with the bottom, and will dissipate it even more if the wave breaks offshore. If, on the other hand, the beach rises abruptly from a deep bottom, more powerful waves will break against the shore.

Most commonly, waves approach the shore at an oblique angle. But because interaction with the bottom causes them to slow down, waves tend to become bent, or refracted, almost parallel to the shore. The portion of a wave encountering shallow bottom first slows down while the section of the wave

over deeper water continues at normal speed. As a result of wave refraction, the energy produced by the breaking waves becomes focused on the headlands, and erosion of these parts of the shore is accelerated. Thus the overall effect of wave refraction is to straighten out irregularities in a shoreline.

The currents that are most important to the development of the shore system arise from the interaction between the waves and the shore itself. Although wave refraction bends waves more or less parallel to the shore, the alignment is seldom exact. Momentum typically carries swash up the beach at an oblique angle, and gravity returns the backwash to the lake. The result is that the surf, and any particles it may carry, follow a zigzag path down the beach. This is called beach drift. For similar reasons, longshore currents develop parallel to the beach within and just outside the zone of breaking waves. The movement of water and the entrained sediment along the shore is referred to as longshore drift.

Beaches

Beaches are accumulations of sediment where land meets water. We tend to think of beaches as being made chiefly or only of sand, but that is not always the case. More common along the south shore of Lake Erie are beaches that are rich in silt as well as sand, with abundant shale chips scattered throughout. Beaches develop out of whatever materials are available: sand and silt from the bottom of the lake, sediment discharged from the mouths of streams, or materials eroded from the land behind the beach. In northeastern Ohio, beaches consist mostly of material eroded from the bluffs behind the beaches.

Once material of any source reaches a beach, it is set in motion by longshore currents, waves and wind. Big storms tend to reduce or destroy beaches. Periods of calm, on the other hand, tend to promote the growth of beaches. But even if a beach appears to be stable, it is not. Beaches are like rivers of sand constantly in motion as the result of beach drift and longshore currents. And cutting off the supply of sediment causes a beach to disappear just as surely as cutting off the water supply causes a river to dry up.

Closest to the water is the beach face, the part of the beach that slopes appreciably toward the water. This is the area most affected by the waves. The steepness of the beach face generally increases with the size of the particles composing it. Beaches composed of pebbles and cobbles tend to be relatively short, with high slopes. Extensive, broad, gently sloping beaches are generally made from sand-sized or silt-sized sediment.

Beaches commonly have an upper zone that contains material tossed up and deposited by large waves. This feature, the berm, slopes gently upward away from the water, ending at some landward feature such as a bluff, cliff, or dune field. Along the shores of Lake Erie there are few dunes because the sediment of the coastal system is notably deficient in sand. As a result, either rocky cliffs (mostly composed of ancient shales) or sedimentary bluffs made of glacial debris or ancient lake bottom deposits make up the landward edge of the shore

region. Although beaches and the bluffs behind them are interactive and part of the same shore system, it should be emphasized that each is a separate feature with its unique and distinctive role in the system.

Shore Erosion Processes

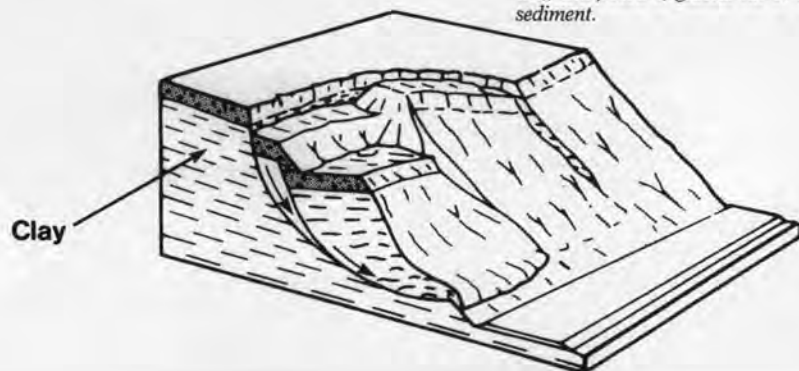
When vacationers speak of shore erosion they usually refer to the narrowing or disappearance of the beaches on which they are accustomed to sit and sun themselves. Lakeshore property owners may bemoan the loss of their beaches, but the shore erosion they worry most about is the retreat of the bluffs on which their homes are built. Along most of the Lake Erie shoreline the two events are related in two distinct ways: the beaches protect the bluffs from the onslaught of the waves; and the eroding bluffs are the most important source of sand and silt for the beaches.

Almost everywhere along the northeastern coast of Ohio both bluffs and beaches are retreating. Bluffs retreat either when waves cut into their lower parts, leaving the upper parts to collapse, or when poor drainage causes the upper portions to become waterlogged and weak, resulting in slumping and sliding. Beaches retreat when more material moves out of the shore system than arrives from elsewhere to replace it.

Erosion of bluffs is most severe during storms, when waves attack their lower reaches. In calm weather, the waves do not ordinarily reach the bluffs. Thus, the concept of "average rates of erosion" is misleading. It is not uncommon for months or even years to go by with little retreat of a bluff, followed by the disappearance of eight or ten feet of material overnight during a single, violent storm. The direction of the winds in the storm, and not just their intensity, helps dictate the erosive potential. In northeastern Ohio, storms that blow in from the northeast traverse the greatest overwater distance because they follow the long axis of the lake. Thus they produce the largest waves, and consequently, the most erosion.

Slumping of the upper portions of bluffs is especially common along the northeast coast of Ohio. When slumping takes place, a fracture, usually concave upward, develops near the outer edge of the bluff, and the block of material bounded by the fracture is pulled slowly downward by the force of gravity, rotating as it falls toward the beach (Figure 1). It may take weeks, months, or even years for the slump block to move all the way down to the level of the beach.

Figure 1
Schematic diagram of a slumping bluff composed of glacial till or lake sediment.



Slumping, mudflows and landslides are particularly acute problems where the bluffs are poorly drained. The ground water in the bluffs acts as a lubricant which facilitates movement. Along many stretches of Ohio's northeast coast, the bluffs are composed of glacial till (sand, gravel, and stones) underlain by relatively impermeable clays that were deposited in lakes at the glacier's edge when the level of the lake was much higher. The contact surface between these two sedimentary units forms a natural passageway for water draining down through the bluffs, and thus forms a lubricated surface along which movement may occur. Surface water runoff also creates problems because it erodes the top and the shoreward face of the bluff.

Some of the bluffs along the Ohio shoreline are made of ancient shale, not of glacial deposits. Not surprisingly, the rock bluffs are more resistant to erosion than are those of glacial silt and clay. The average rate of retreat of the till and clay bluffs is about three feet per year. But even the shale bluffs are not solid and stable. Because of their numerous bedding planes and tendency to split, water can easily penetrate them, freeze, expand, and pry them apart. Then it is a relatively easy matter for the waves to carry them away.

The extent to which beaches have narrowed or disappeared over the past two centuries is remarkable. "When the first settlers of the Western Reserve came along the Ohio shore, in 1796, the sandy beach of the lake was occupied as a road throughout, and was used for that purpose east of Cleveland many years."² For northeastern Ohio, this is clearly ancient history.

It may come as a surprise to a frustrated property owner fighting to protect his bluffs that he is in fact a major contributor to the beach erosion problem. Studies by Charles Carter, Donald Guy, and others at the Ohio Department of Natural Resources correlating the development of man-made structures along the Lake Erie shore with changes in the form of the shoreline since 1876 are very definitive in this respect. These studies report that, overall, the bluffs have been retreating since 1876, although more recently the rate of erosion has greatly diminished. In places, bluff erosion seems to have ceased entirely. On the other hand, the rate of disappearance of beaches has actually increased in recent times, even in periods of relatively low lake levels. In addition, there has been an increase in the irregularity of the shoreline.

Since 1876, there has been a marked increase in the number and size of shore protection structures and harbor structures. The harbor structures are largely breakwaters and jetties, built to keep river mouths navigable and to diminish the effect of waves. The shore protection structures consist mainly of seawalls and groins (walls built perpendicular to the shore). The purpose of the seawalls is to armor the shore against the effects of waves, whereas the groins are built to trap the longshore drift of sand, causing beaches to become wider.

The reported impact of these structures on the shore system was not surprising to geologists. A harbor structure can actually increase the rate of shore erosion on its downdrift side. That is, a large jetty intercepts the longshore drift of sand

on its updrift side, thereby starving the shoreline on the downdrift side of the sediment needed to maintain the beaches. Updrift of the jetty, beaches often grow wide. Downdrift, they narrow or disappear, exacerbating erosion of the bluffs behind them.

The findings concerning the shore protection structures are filled with irony. The seawalls, by armoring the shore behind them, reduce or locally eliminate the retreat of the bluffs. But along the Lake Erie shore the eroding bluffs contain the sand and silt that nourishes the beaches. Because beaches are so dynamic, this sequence creates a problem only when a large proportion of the bluff along a stretch of coastline is protected. But over the years, exactly that has happened. The sand and silt supply from the bluffs has diminished and the beaches have suffered. Protecting the shore from erosion has upset the natural shore process that had been creating and maintaining beaches. Even more ironic is the fact that beaches are the best line of natural protection against bluff erosion. As a result of these good intentions, ever more strenuous measures must be taken to protect the bluffs.

The application of shore erosion protection measures, then, has produced an unforeseen and undesirable impact on shore processes. But there is a significant aesthetic effect, as well. Shore protection measures have been frequently applied in a haphazard manner, and all kinds of materials have been dumped into and along the lake to stop the erosion. As a result, not only have these measures resulted in the loss of beaches but they have produced an unsightly spectacle along the shoreline. We have not done sufficient research to be certain, but it is probable that if most bluff erosion measures were ended, many former beaches along the shores of Lake Erie would become reestablished.

The erosion of the Lake Erie shoreline in northeastern Ohio should be seen therefore as the result of many factors operating together, including wave intensity, bluff resistance, drainage, and even the nature and number of man-made structures placed within the shoreline system. One factor though, not considered so far, seems to be of particular importance. This is the level of water in the lake.

Lake Level Fluctuations

Lake levels fluctuate by a foot or two during a typical year, rising through the spring and early summer when runoff is at its peak, and falling during the autumn and winter. Water levels also fluctuate from year to year. During the past 120 years, the level of Lake Erie has gone up and down in a range of about five feet (Figure 2).

The most bitter and vehement debates about lake levels center around the question of the extent to which the levels are governed by natural processes, and the extent to which the government, especially the United States Army Corps of Engineers, has maintained water at high levels, to the detriment of

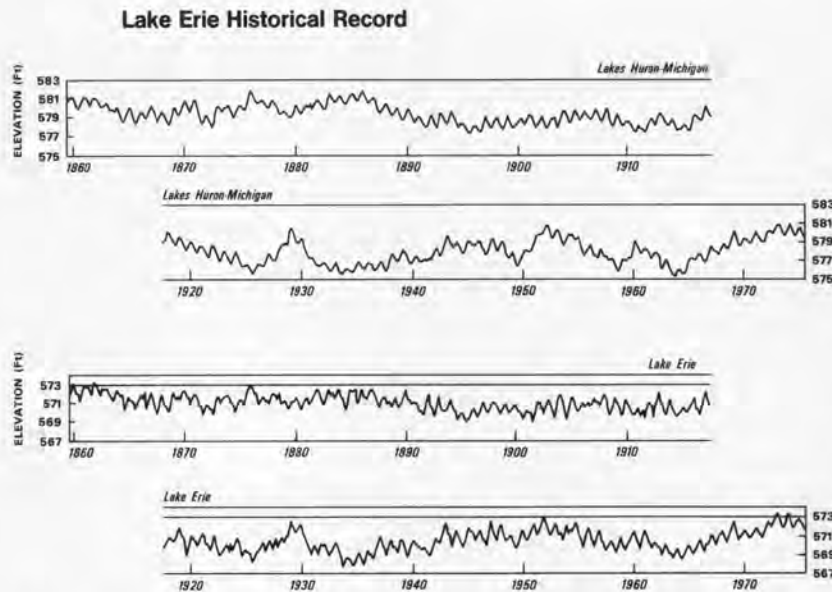
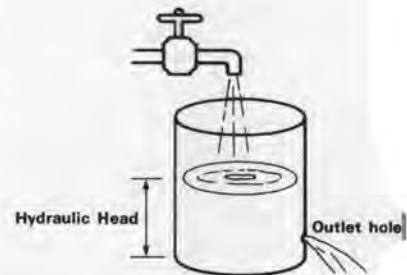


Figure 2
Historical record of water levels in Lake Huron/Lake Michigan and Lake Erie. Taken from Further Regulation of the Great Lakes (International Joint Commission, Canada and United States, 1976).

shore interests and the benefit of shipping and power interests. The Corps of Engineers asserts that the level of Lake Erie is unregulated, that is, that there are no control structures, or other engineering works that can be readily adjusted to increase or decrease the rate of flow into or out of the lake. But this does not mean that the level of the lake is where it would be if civilization, or the Corps itself, had not intruded into the region. Over the years, a series of engineering projects have been completed, which while not variable or adjustable, have had an impact on the level of Lake Erie. These include a series of diversion projects in the Upper Great Lakes and the diversion of water through the Welland Canal.

It is easiest to understand the factors controlling the level of the lake in terms of a water budget. The rate at which water comes into the lake is referred to as *input*, and the rate at which water leaves is referred to as *output*. If inputs exceed outputs, the lake level rises. If the reverse occurs, the level falls. But because the output is, in part, related to the water level, the lake level is to an extent self-stabilizing. This can be visualized by analogy with the flow through a tin can as shown in Figure 3. Water flows into the can from a faucet above and flows out through a hole in the side near the bottom. The input is determined by external conditions, i.e., by the position of the faucet handle. But the output depends on how high the water level is. The higher the water in the can, the higher will be the pressure at the outlet (the hydraulic head) and the more rapidly will water flow out. As the can begins to fill, output increases, until at some point it becomes equal to the input. That condition is referred to as a *steady state*. Water flows in the top and out the bottom of the can, but the water level does not change. If the input at the top is increased or reduced, the water level rises or falls until a new steady state water level is achieved. In response to changing inflow, the level of water in Lake Erie, in many respects, fluctuates analogously to the tin can.



**RATE OF INFLOW IS CONSTANT
RATE OF OUTFLOW DEPENDS ON**
• Hydraulic Head
• Size of outlet hole

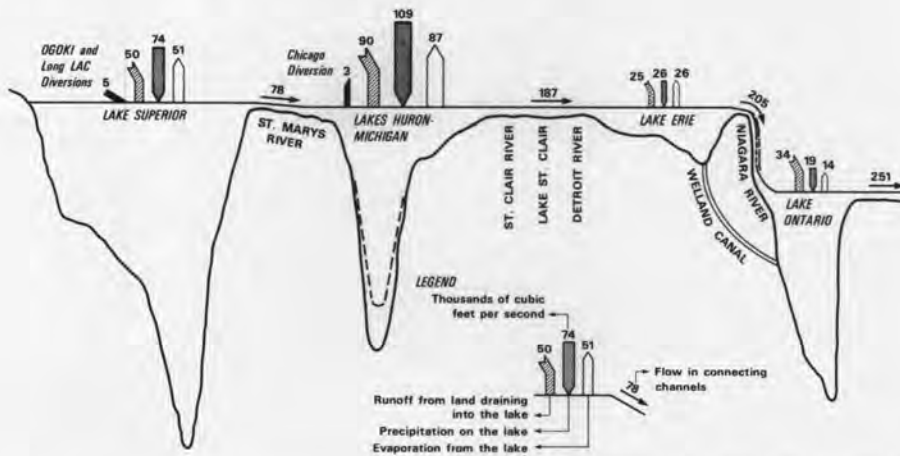
Figure 3
The level of a lake is, to an extent, self regulating. That is, the rate of outflow increases as the water level rises, as in the tin can illustration. If the rate of inflow is less than the outflow, the water level drops; but the rate of outflow also drops. Eventually, a steady state is reached, i.e., the rate of outflow exactly equals the rate of inflow. If, then, the inflow is decreased or increased, the water level will fall or rise accordingly, until a new steady rate is reached.

The major inputs of water into Lake Erie, and their approximate magnitudes, are shown in Figure 4. It is a relatively easy matter to measure the flow from the upper Great Lakes, since that all comes through a channel consisting of the St. Clair River, Lake St. Clair and the Detroit River. Because rainfall is measured at many places, it is not especially difficult to estimate the amount of rain that falls directly on the lake surface. But the lake also receives some fraction of the precipitation that falls on the entire drainage basin. Part of that arrives at the lake as surface runoff, flowing through many streams and rivers, and to a lesser extent simply running off the land surface into the lake during rainstorms. And some of the rainfall to the drainage basin percolates into the lake in the subsurface. That fraction is generally assumed to be small, but it is extremely difficult to estimate.

The major outflows from the lake are also shown in Figure 4. The Niagara River takes the greatest amount of water, and outflow into the river has been documented for many years by the Corps of Engineers. The behavior of that outflow is similar to the flow out of the bottom of the can. The higher

Inputs, Outputs, and Lake Levels

Hydrologic Factors Affecting Water Supplies to Each of the Great Lakes



NOTE: The numbers above the symbols for the hydrologic factors are average values for the period October 1950 to September 1960.

the water level, the greater the outflow. Additional water leaves Lake Erie through the Welland Canal, and that output has also been monitored for many years by the Corps. But a third avenue for loss of water from Lake Erie is evaporation from the lake surface. The rate of loss by evaporation is independent of lake level. It depends upon meteorological conditions—especially relative humidity, wind and temperature.

Diversion is the term used for the transport of water out of one drainage basin into another. The earliest major man-made diversion of water from the Great Lakes system was the movement of Lake Michigan water from the Chicago area southward into the Mississippi River system, initially authorized in 1822 and begun in 1848. This diversion has been modified or completely relocated and rebuilt several times

Figure 4
The water budget of the Great Lakes, taken from Further Regulation of the Great Lakes (International Joint Commission, Canada and United States, 1976).

since then. It serves both for navigation and for the transport of Chicago's sewage out of the Great Lakes system. The effect of this diversion is to lower the level of Lake Michigan and consequently that of Lake Erie. The amount of water diverted at Chicago has varied over the years, reaching a maximum in the 1920s. By decree of the United States Supreme Court in 1967 the maximum amount of water allowed to be diverted there was set at a value of approximately one third of the 1928 maximum. Those who lament the role of government in causing Lake Erie water levels to rise often point to the decreased outflow at the Chicago diversion as an example. At present rates of water flow, according to the International Joint Commission (IJC)—the U.S. and Canadian binational organization charged with overseeing Great Lakes matters—the Chicago diversion has the effect of lowering the level of Lake Erie by approximately 0.14 feet. Operating at its maximum rate in the 1920s, the diversion may have lowered the level of Lake Erie by as much as half a foot, or about four inches more than it does today. That is a small amount, but it is sufficient to exacerbate shore erosion problems, especially at times when they are already severe. Depending on one's point of view, the decreased diversion at Chicago can be seen either as having caused an artificial increase in the level of Lake Erie or as having caused the lessening of a man-made decrease, i.e., a return to a condition closer to the natural.

Two additional diversions, Long Lac and Ogoki, channel water out of the Hudson Bay drainage and into the Lake Superior basin. These diversions were built in the late 1930s and early 1940s by Canada with the agreement of the United States. The Long Lac diversion was built in part for floating pulpwood, and both were built for hydroelectric generation. Because of the increased amount of water it brought into the Upper Great Lakes system by these diversions, Canada was permitted to increase the amount of water directed to Canadian hydroelectric plants at Niagara Falls, far down the system. The amount of water brought into the Great Lakes system by these diversions has been calculated by the IJC to raise the water level of Lake Erie by about three inches.

The last major diversion that significantly affects the water level in Lake Erie is the Welland Canal, which flows from Lake Erie to Lake Ontario. This canal was first completed in 1829 and has been rebuilt or enlarged several times since then, each time increasing the amount of water diverted. It is used for shipping and provides water for electric power generation. At modern flow rates through the Welland Canal the level of Lake Erie is estimated by the IJC to be lowered by a little more than five inches.

The net effect of the Chicago, Long Lac and Ogoki diversion projects and the Welland canal is to drop the level of Lake Erie about four inches below what it would be in the absence of human intervention. This is not the entire story, however. The Corps of Engineers considers Lake Superior to be a regulated lake. Flow from Superior into the Lake Michigan/Lake Huron system is regulated by control structures at Sault Ste. Marie on the St. Mary's River. By decreasing the flow at this structure the level of Lake Superior can be

increased while that in Lakes Michigan and Huron, and eventually in Lake Erie, become lowered. In the Spring of 1986, when Michigan, Huron, and Erie were at record high levels and shore properties were severely threatened, this was done. But the maximum effect at Lake Erie, which was not to be felt until the following autumn, was to be only about two inches.

Shipping from Lake Erie to Lake Huron goes through the Detroit River, Lake St. Clair, and the St. Clair River. The shipping channels in the rivers have been widened several times, most recently in 1962, by dredging, in order to accommodate ships of deeper draft. The claim has been made frequently by owners of threatened shoreline property that in spite of denial by the Corps of Engineers, the widening of this channel has been a major cause of the high lake levels we have experienced since the low water period of the early and middle 1960s. For the reasons to be discussed below, we do not believe that the widening of the channel could have caused a permanent, long term increase in the level of Lake Erie, although it could have caused a temporary or transient rise, the effects of which should be largely dissipated by now.

The effects of enlarging the channel draining Lake Huron on the water levels of both Erie and Huron can again be seen through another tin can analogy. When the outlet in the upper can is enlarged, the water level in that can experiences a permanent drop while the level in the lower can experiences a transient rise and a return to original levels. The IJC has reported that a transient increase occurred in the level of Lake Erie following the widening of the St. Clair River/Detroit River channels, and that the transient had passed by 1969, only seven years after the dredging. We have not been able to detect any effect on Lake Erie water levels caused by widening of the channel feeding the lake, except perhaps between 1963 to 1969.

One last structure that has been frequently blamed for the high water levels of Lake Erie is the weir on the Niagara River at the Grass Island Pool, just above Niagara Falls. This structure is something like a dam that goes only halfway across the river. It was built to control water flow into a hydroelectric plant, and some argue that it sufficiently retards the flow of water out of Lake Erie that lake levels have been raised. We find no support for that argument. The weir is approximately one hundred feet below the level of Lake Erie. It is simply too far downstream on the Niagara River and too far below the level of the Lake for it to cause any backup of water into the Lake.

If man is not primarily responsible for the high lake levels of recent years then what is? Three years ago we produced a television documentary on Lake Erie shore erosion. At that time we rather trustingly accepted the claims and conclusions of the Corps of Engineers and the International Joint Commission that the level of Lake Erie was not regulated. After the show was aired we received a number of angry letters from viewers who felt that the Corps was at the root of their erosion problems. The message of many of those letters was that we were liars or dupes and we had better be able to back up our claims. We have now examined a great deal of data on

Figure 5

It can be argued that the main control on the level of Lake Erie is the level of Lake Huron. Each point on the graph is the mean water level for a calendar year.

The open circles represent the years 1925 to 1962 (prior to the last dredging of the Detroit and St. Clair Rivers); the solid circles are for years 1962 to 1984.

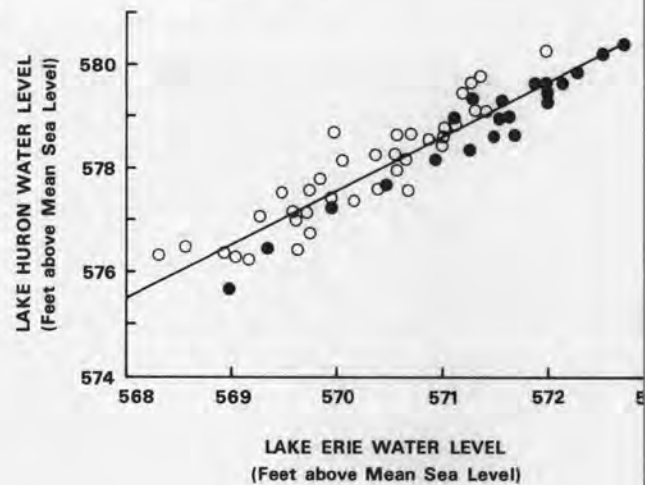
The data for the entire time interval fall along the same line which indicates that the dredging caused no permanent change in the level of Lake Erie.

lake levels and precipitation in the Great Lakes. True, the data we have examined have come from the Corps, but it seems highly unlikely that this sort of data could or would be purposely falsified in order to deceive the public.

Our conclusions are unremarkable. The level of Lake Erie is controlled primarily by the level of Lake Huron. The level of Lake Huron fluctuates primarily as precipitation in the Huron/Michigan basin fluctuates. And much of the relatively small fluctuation in the level of Lake Erie that cannot be correlated with the level of Lake Huron can be correlated with precipitation in the Lake Erie basin. Figure 5 shows the relation between mean annual lake levels in Lakes Huron and Erie from 1925 to 1984. The correlation between the levels of the two lakes is clear. The scatter of data points about the line is, with one exception, less than about nine inches, quite small compared to the total range of water levels of almost five feet. And the correlation is essentially the same for the pre-1962 water levels as it is for the years since the widening of the St. Clair/Detroit River channels.

In Figure 6 we have examined the relationship between precipitation in the Lake Huron/Michigan basin and the level of Lake Huron. It is clear that there is a relationship, although there is a considerable amount of scatter about the line through the data. Precipitation data are shown as five-year moving averages. The scatter would have been even greater if we had plotted annual precipitation. Precipitation can vary enormously, sometimes doubling from one year to the next, and a typical drop of water stays in the lake for a number of years before evaporating or flowing out. So the level of Lake Huron reflects precipitation over an extended period of time.

HURON AND ERIE WATER LEVELS COMPARISON 1925-1984



LAKE HURON LEVEL AND PRECIPITATION PRECIPITATION 5 YEAR MOVING AVERAGE

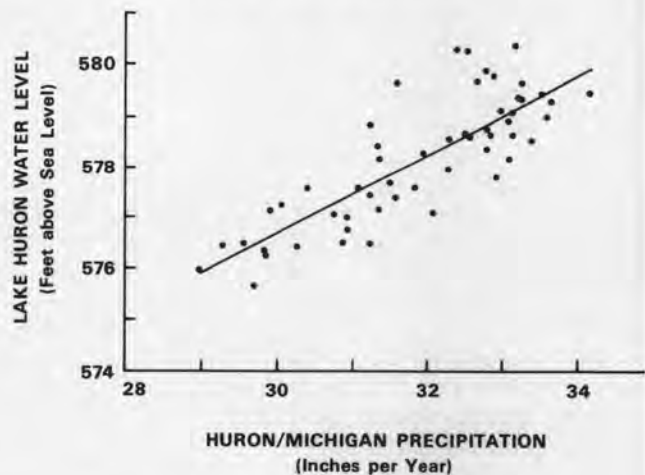


Figure 6

The level of water in Lake Huron is closely related to the annual precipitation in the Lake Michigan/Lake Huron drainage basin. Precipitation is plotted here as a five-year moving average in order to minimize the effects of year-to-year fluctuations and emphasize the effects of long-term climatic trends.

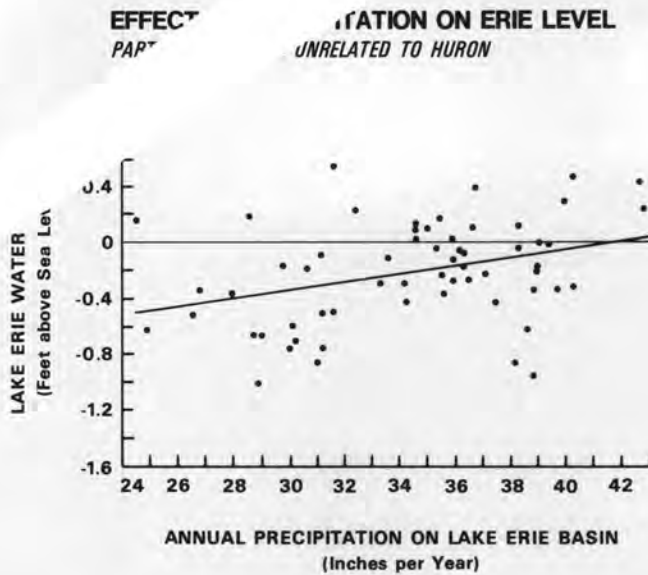


Figure 7

A relatively small part of the fluctuation in Lake Erie's water level is not accounted for by the fluctuation of Lake Huron. That amount is represented by the scatter of dots about the line drawn on Figure 6, and is related to the annual precipitation on the Lake Erie drainage basin.

Finally, we look at that portion of the level of the fluctuations of Lake Erie that cannot be correlated with the level of Lake Huron, i.e., the part of the fluctuation of Lake Erie that gave rise to the scatter of data points about the line in Figure 5. It can be seen in Figure 7 that this correlates, although admittedly not spectacularly well, with precipitation on the Lake Erie basin.

As a result of this study we are confident that we understand the most important factors controlling the fluctuations in the level of Lake Erie, and that those factors are largely of natural origin. The high lake levels of recent years are the result of high precipitation, especially in the Upper Great Lakes. Water levels were at record heights in 1986 and early 1987, but the record was not broken by a large amount. The water in Lake Erie was at almost as high a level in 1860, before man had significantly perturbed the system.

If governmental assessments can be relied on, the level of Lake Erie is a few inches lower than it would be if the Great Lakes system were in a completely natural state. An increment of a few inches in the water level can mean a great deal of incremental damage to shore property in a big storm when levels are already high. There is no doubt that the water level in Lake Erie could be made even lower. The important question then becomes *whether* the level should be lowered, and if so, who should pay the cost.

The Politics and Economics of Water Level Control

Bureaucrats divide those who are affected by the level of water in Lake Erie into three constituencies: shore interests, shipping interests, and electrical power generating interests. The constituency of shore interests includes property owners, pleasure boaters, and all of us who enjoy a day at the beach

(when there is a beach to be found). By and large this constituency benefits from low water levels. Erosion problems are minimized and beaches are largest when levels are low. As long as levels do not drop too low, low water levels benefit marinas and small boat harbors as well. On the other hand, when water levels are high, large ships can carry more cargo, and there is more water available for the generation of hydroelectric power in the Niagara Falls region. In recent years, when water levels have been high, there have been many calls on the part of shore interests for government to lower lake levels. Of those who are persuaded that the government is deliberately keeping lake levels high to benefit shipping and power interests, some feel that government has deliberately raised the level of Lake Erie while others blame government only for failing to take steps to lower the level. Although there seems to be no justification for believing the former, the latter is clearly true. Whether government *should* take steps to lower the level of Lake Erie is more a matter of politics and economics than of geology.

By treaty between the United States and Canada, decisions about changes in the levels of the Great Lakes must be decided bilaterally, by the International Joint Commission. On several occasions, the most recent one in 1981, the IJC conducted investigations of the consequences of regulating the level of Lake Erie, and made recommendations on what should be done. (Ironically, a 1964 study was prompted by low, not high, water levels.) The approach taken in these studies has been to attempt to assess the impact of artificially modifying lake levels on the economy and the environment. Both of these assessments are fraught with uncertainties. The IJC has consistently concluded that regulation of the level of Lake Erie would have a negative economic impact. That is, the costs would outweigh the benefits.

The executive summary of the 1981 report stated that "the magnitude of the losses compared to the benefits is such that no reasonable changes in assumptions or evaluative techniques could result in net benefits approaching the cost of the . . . regulatory works" proposed for the regulation of Lake Erie. Nevertheless, in the summer of 1986, with Lake Erie at record high levels, plans were underway to reopen the question. Among the changes in circumstances that might alter the outcome of the new study are: the decrease in the traffic of large ore carriers on the Great Lakes in recent years; diminished expectations for the development of nuclear power and the associated "consumptive use" or permanent removal of water from the Great Lakes for cooling; and the unusual amount of damage to shorelines and shore structures caused by the record high lake levels of the middle 1980s.

A Sane Coastal Region Policy

A five-point policy is proposed for the use and protection of the coastal zone of Lake Erie and of all the Great Lakes.

1. The shoreline should be zoned off-limits for new construction for a distance from the lake equal to the expected retreat

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of the shoreline during an extended period of time, ideally, the next two hundred years. That distance varies locally, but is typically between 200 and 800 feet.

2. To the extent possible, state and local governments should convert the coastal zone into parkland. Erosion should be allowed to take its course in those parks, thereby providing sand to nourish the beaches.

3. Legislation should require that, when real estate in coastal zones is transferred, properties be surveyed for erosion risks. Buyers should be provided with the results of such surveys prior to purchase.

4. The government should not build breakwaters or other structures to protect private property, but should continue to provide information about the effects of and remedies for erosion.

5. Protective measures should be permitted, although not encouraged, for property on which improvements now exist. No protective measures should be permitted for property which is not now improved or from which improvements are removed in the future.

Shore erosion is a geological phenomenon which becomes a human problem only when humans act in ignorance or defiance of the geological realities. The best solution is education and the promulgation as well as enforcement of scientifically sound regulations concerning coastal use and development. ■

Notes

¹However, we know of at least one video feature that is, in our opinion, an excellent treatment of the topic. It's entitled "The Lake at Our Doors" and, coincidentally, was produced by us and written by our good friend Tom Hallet. Copies of this twenty-five minute videotape are available for loan from the Departments of Geological Sciences both at Cleveland State University and Case Western Reserve University (Cleveland, Ohio, 44115 and 44106, respectively).

²C. Whittlesey, "Geological Report," *Ohio Geological Survey, Second Annual Report* (1838), 41-71.

The Great Lakes



The Great Lakes Exposition of 1936

Michael T. Gavin

At noon on June 27, 1936, Cleveland's centennial year, President Franklin D. Roosevelt pressed an electric button at his desk in the White House: in Cleveland the locks of twenty turnstiles clicked open, the band struck up the Star-Spangled Banner, and the Great Lakes Exposition was under way. Fireworks exploded over the heads of the huge crowd outside the main Exposition entrance on St. Clair Avenue. The skies were filled with red, white, and blue parachutes. A thousand pigeons were released carrying invitations to the Great Lakes celebration in all directions. Thirty thousand visitors passed through the turnstiles in the first half hour. The idea of an exposition to celebrate Cleveland's "romance of iron and steel" and the Great Lakes region's industrial strength had taken only ninety days to become a reality.

According to the organizers' prospectus, the exposition was intended "To advance the industrial and civic interest of Cleveland through an undertaking in which the entire citizenship would find inspiration; To advance the business interests by attracting hundreds of thousands of visitors who would patronize commercial institutions, become better acquainted with local products, and see first-hand the advantages of the city as a place in which to live and have a business . . . ; To further the efforts of civic and business organizations through stimulating pride, faith, and community patriotism; To lay the foundation for the work of securing future conventions and expositions through demonstrating Cleveland's ability to take care of important events; To imbue in every man, woman, and child in Cleveland a newborn confidence in the power of the community to go forward under the concerted leadership that will achieve its due recognition through this enterprise."

The industrial expansion of 1900-1930 had created twenty million jobs for the nation, many in the Great Lakes region. Commerce on the Great Lakes exceeded the foreign commerce along the Atlantic, the Pacific, and the Gulf ports. More than one-third of the nation's people lived there, and the eight Great Lakes States were producing well over half of the United States' iron ore. Of this, about 85% was controlled by Cleveland organizations, including the Cleveland Cliffs Iron Company, the Oglebay, Norton & Co., the M.A. Hanna Co., the Corrigan-McKinney Co., and the U.S. Steel Corporation.



Michael Gavin's interest in the Exposition of 1936 was sparked by some cocktail conversation with a woman who was involved with a commemoration of the exposition. Soon after, he found himself writing about "an event I never attended that happened fifty years ago." Gavin, who is editor of the Bedford Times-Register, is currently working on his M.A. in English at Cleveland State University. His B.A. is from St. Bonaventure University. After finishing his thesis, he plans to continue writing, and possibly to live and work in a third-world country. He lists among his interests the arts, the environment, his thesis, and fast cars.

Cleveland was the headquarters for the Lake Carriers Association, the Ore and Coal Exchange, and other Great Lakes commercial organizations as well as the United States Coast Guard. In the first four decades of the century, more than fifty companies manufactured cars here.

An opinion column in *The Cleveland News* (1935) urged, "Now the country is getting out of the depression, and Cleveland should show the whole U.S. in 1936 that it is leading the procession." Construction of the new Terminal Tower, Severance Hall, the Stadium, and the Arena seemed to justify such optimism. In early June of 1936 the Republican Party came to the city to nominate Governor Alfred M. Landon of Kansas for President. The Socialist National Convention had met here in May, the National Air Races took place on Labor Day, and the American Legion convention met in September.

Cleveland's rise to industrial preeminence had not, however, been without concessions. A few civic-minded citizens had pleaded for preservation of the lakefront, but city and county authorities allowed the lake and river to be sacrificed to the necessities of shipping, industry, and waste disposal. Now organizers hoped that the exposition would refurbish the blighted area.

Commercial expectations were also high. The officers of the massive Great Lakes Exposition project, headed by Dudley S. Blossom, were reasonably sure they would not lose the \$1,100,000 they had pledged to underwrite it. On April 21, the participation of the federal government was assured by the passage of a bill authorizing the expenditure of \$275,000 for the Great Lakes Exposition.

A work force of 2,784 constructed the Great Lakes Exposition buildings in only three months; WPA laborers laid out gardens throughout the exposition grounds. All this occupied the Mall from St. Clair Avenue north, the Public Auditorium, and the lakefront from West 3rd Street to East 20th Street—an area of more than two square miles, most of which had been a dumping ground. More than sixty thousand people passed through the seven stately pylons marking the main entrance, to eat, drink, look at pretty girls, gape at industrial exhibits, hear music at the orchestral shell on the Mall, enjoy carnival rides, and subject themselves to the blandishments of barkers and the attractions of the exhibits.

Senator Robert D. Bulkley, an exposition trustee, received a telegram from President Roosevelt: "An engagement with which you are familiar [Roosevelt's acceptance of the Democratic nomination for president] and which will require my presence in Philadelphia, will prevent my personal participa-



Bird's eye view of Exposition location on the lakefront.

tion But I cannot restrain the impulse to give you this assurance of my sincere wishes for the success of the undertaking." Roosevelt eventually visited the exposition on August 14, 1936, making a forty-mile circuit of the Cleveland metropolitan area, reviewing the WPA projects, and concluding with lunch on the S.S. Moses Cleaveland.

On the evening of opening day, the Warner & Swasey observatory on Taylor Road focused a telescope on the moon's path. Forty minutes after sunset the rotation of the earth brought the moon into the telescope's field, and, just as planned, tripped an electric eye hooked up to a switch which lit up the entire exposition.

The exposition used up-to-date lighting effects that combined indirect light with color to create a man-made aurora borealis. Powerful rainbow-colored rays were sent into the sky to form an expanded fan of light above the Marine Theatre, visible from any part of the grounds.

William M. Milliken, director of the Cleveland Museum of Art, brought several famous art collections to show at the exposition museum. Along with the International Exhibit of the Carnegie Institute were seventy-two art works from private Cleveland collections.

The Lakeside Exhibition Hall housed the "Romance of Iron and Steel" exhibit which portrayed this industry from Duluth to Buffalo. The exhibit began in a hillside built to resemble the rich Minnesota ore ranges, opening into a life-sized mine shaft with walls of red iron ore. Within the shaft were underground tracks and switches for ore cars. Further along, a large map of the Great Lakes region showed the iron, coal, and steel commerce of the lakes. Murals depicted loading and unloading machinery which filled and emptied six-hundred-foot freighters in a few minutes.

The Hall of Progress drew some of the biggest crowds. Visitors were able to sit at a large circular desk at the Ohio Bell Telephone Company exhibit, speak into a phone, and hear their voices played back to them.

Fatigue and tired feet could be alleviated with buses, push-cars, and jinrickshas pulled for a dollar an hour by college students. The Streets of the World section was lined with sidewalk cafes and shops representing nearly thirty nations. Strolling gentlemen in white shirts, black trousers, and red sashes sang "O Sole Mio" while traveling the circular paths of the village. More than four hundred buildings were crowded

Strolling the Donald Gray Gardens.



together on the acres devoted to the Streets of the World exhibit. The tiled and tiered roof of a pagoda stood outlined against the white bulk of an imitation Swiss Alp. Slovenian peasants danced, Hungarian gypsies performed, German bands played beer garden music, and Russian Cossacks bounded about to an eight-piece Russian orchestra. At the Alpine Village a regiment of waiters dressed in leather breeches yodeled lustily as they carried trays of beer steins.

The French Casino had five terraced floors and accommodated fifteen hundred people. The scantily dressed dancers were subjected to special spotlights which caused their costumes to become scandalously transparent. The showstopper was Miss Toto Laverne who wore only an imitation swan's neck while prancing around the floor in the manner of Chicago's Sally Rand.

Cleveland's social elite and important dignitaries hobnobbed at the Admiralty Club on the S.S. Moses Cleaveland, served by staff members in fancy uniforms. The Western Reserve Historical Society displayed portraits, historic objects, and documents associated with Moses Cleaveland, as well as a log cabin replica of the birthplace of President Garfield.

At the shoreline the Marine Theatre featured aquatic dancing, diving, and swimming acts. The Hall of Progress awed people with exhibits like the first air-conditioned motor bus, which even had a drinking fountain in it. The bus, an exhibit of the White Motor Co., had a lounge seat with two small service bars in the back end. According to a contemporary description, "Not the least remarkable of its features is that a six-foot man can actually stand erect in its aisle, wearing a hat, without scraping the roof."

A replica of the Globe Theatre housed performances of shortened versions of several Shakespeare plays. The Symphony Orchestra, which included Cleveland Orchestra musicians, played nightly in programs directed by Rudolph Ringwall and other visiting conductors.

Donald Gray's Horticultural Gardens stretched along the water line and displayed rare plants, waterfalls, rock gardens, large fountains, and a reflecting pool. A series of seventy-nine garden plots and miniature waterfalls were skillfully scattered along winding paths, illuminated at night for late strollers. The tri-level Horticultural Building looked like the stern of an ocean liner.

The Firestone Exhibit was complete with waving fields of grain, a barn, farmhouse, implements shed, live cows, chickens, horses, ducks, and goats. The 180,000-square-foot display also demonstrated every phase of tire-making, and delighted visitors with its singing, colored fountains. Six misty fountain domes rose from a pool 120 feet long and 20 feet wide. Colored plumes of spray shot high into the air with synchronized accuracy following tonal variations in the music.

The general admission price of fifty cents gave access to many of the exhibits. For a little extra visitors could enjoy boat rides on Lake Erie, Goodyear Blimp rides (\$3.00), and assorted other amusements. Or people could visit the Front Page exhibit and listen to John Dillinger Sr. talk about his son and assure youth that crime did not pay. In the Public Auditorium was the largest broadcasting studio in the world, Radioland,



*Scantily dressed
Miss Toto Laverne.*

which featured well-known acts such as Fibber McGee, Irene Rich, and Uncle Ezra. The Cleveland Stadium held daily athletic events and spectacles.

Visitors from all forty-eight states converged on Cleveland. On a rainy Fourth of July, attendance reached 54,535. The following day set the Great Lakes Exposition record of 68,256—the exposition was averaging 37,600 per day for the first nine days. A *Plain Dealer* article read: “The dream beauty comes true. The dusty Cinderella of the neglected lake front blossoms into the lovely lady, suave and seductive, who is the Great Lakes Exposition.”

A crowd of 274,092 visited the exposition over Labor Day weekend. The scheduled 100-day running time was increased to 108 days. When the 1936 Great Lakes Exposition concluded on October 8, almost four million people had passed through the turnstiles. General chairman Dudley S. Blossom presented a positive financial report and urged continuation of the project in 1937; the proposal was adopted unanimously.

“The Making of a Nation” was the theme for the 1937 version, which exhibited a huge ice skating spectacle called Winterland and an extraordinary dancing, singing, swimming production in Billy Rose’s Aquacade. Set on a 160-foot floating stage surrounded by miniature battleships plying the Lake Erie waters, the production included nine famous bands and five hundred performers, among whom were Olympic swimmers Johnny Weissmuller and Eleanor Holm.

At 10:10 p.m. on the last day of the 1937 Great Lakes Exposition thousands gathered around the Radioland shell, joined hands, and listened as a quartet sang “Auld Lang Syne.” More than seven million visitors brought approximately \$42 million into Cleveland trade channels. The “tin can lake-front” had been turned into a thing of beauty and it was hoped that Cleveland’s shoreline would remain that way.

Now, however, the only physical reminder of the lakefront festival is the Horticultural Gardens which were renamed to honor their maker, Donald Gray, following his death May 30, 1939, at age forty-eight. Attempts have been made to maintain the property and the gardens but their once great beauty is gone. Gone also is the five-hundred-foot long hilltop pergola where now there are only cracked and leaning concrete pillars. The waterfalls have been disassembled and the reflecting pool holds only black stagnant water and debris. The stones which line the tiered pathways have shifted and are moss covered. The once inspiring view that garden strollers had of the lake is now blocked by the buildings of the Cleveland Port Authority. With some exceptions, the 100,000 plants, shrubs, and trees of world-wide variety have disappeared because of the punishing lakefront weather and the absence of a gardener’s care.

Donald Gray, who wrote a daily column on gardening and civic improvement in the *Cleveland Press*, believed that the Great Lakes Exposition was just an example of what could be done all along the city’s shores. The chairman of the exposition’s Horticultural Gardens, Mrs. Robert H. Jamison said, “His magnificent gardens should be restored and maintained as a public park, not only for the pleasure they can give, but to remind us again that our city can be beautiful.”



*The art-deco style
Gray Horticulture
Exhibition Center.*

The fate of the gardens has not yet been decided. The property of the City of Cleveland, they had been considered for landmark designation by the Cleveland Landmark Commission, an organization to preserve historic sites, but have not yet been so distinguished. The commission's director, John D. Cimperman, has said that their restoration "would offer Clevelanders not only a much needed retreat near the lake and Stadium, but could be symbolic—as Gray intended the gardens should be—of what can be done all over the city to beautify it." Planning for the gardens is still a long way off, however.

According to Paul Svedersky, executive director of the Waterfront Coalition, local landscape companies donated their time to the gardens in 1986 to help with the maintenance. Construction of the Inner Harbor project taking place near the gardens will extend over the next five years.* The Donald Gray Gardens are not yet part of that project, although the possibility has been discussed.

At the time of the exposition a Cleveland *Press* writer took note of Cleveland's discovery of one of its greatest natural resources: "During its recent history, Cleveland had neglected its greatest asset—the lake and its shores. A large part of the population have lived as if Cleveland were an inland city. Now the people are discovering, to their amazed delight, that Cleveland is indeed a city wedded to the water. It will be hard for any administration to let it continue to lie, forgotten and unused, a no man's land of bleak stagnation, a shambles of dirt and grime." Now, fifty years later, renewed interest in Cleveland's shoreline focuses on the same spot where the Great Lakes Exposition stood—its buildings long torn down, its horticultural gardens neglected, its celebration of the lakefront forgotten. Perhaps this time the city and the politicians will not lose interest. ■



*The neglected garden
site, behind Cleveland
Municipal Stadium
(1980).*

* For more information on this project, see "Redeveloping the Cleveland Lakefront," pp. 74-79.

The Great Lakes



Inland Sailor

Poems and Photos by Alan MacDougall

In 1970, Alan MacDougall set out to hitchhike around the country, but his journey was detoured for thirteen years while he worked as a deckhand and watchman on the Great Lakes steel boats. About four years ago, he began to rework the poems (over four hundred) in the journals he had kept during this "wandering period." More than eighty of the poems have been published in such journals as Poetry Now, Poetry Review, Grand River Review, and MacGuffin. "My goal is to bridge the gap between my poetry and the local appliance repairman, the housewife, the Kansas City flight attendant or the farmer in Minnesota. I want them to recognize it. I believe that sound rhythms are important carriers of emotional resonance, possibly touchstones even, and that this is where the more general audience might be picked up again. To stay simple—rhythm, body, blood, song—seems like a decent goal, whether or not I can achieve it." Some of MacDougall's poems have been collected in an as-yet-unpublished manuscript, "Inland Sailing," from which the following poems have been taken. Editor of Toolbox, a collection of poems by Detroit working men (published in 1985), MacDougall also speaks six languages and wishes it were possible to get to heaven without dying, an experiment that he says is still in progress.



Clearing Port

In the pewter silver sky deep water mirror,
lapping against the boat's side, far under
in the reflected heavens, Polacks, dressed
as Indians, crying away some old sin, dancing
and praying to the God of iron and tin.
Great Lakes' sunset—orange wash and crackling
embers, suffused in smoke and cream blues.
When the boy said time and a half and double
time and a quarter, cleared one hundred and
ninety in six days, he didn't mean that.
How else could he express the comradeship,
loneliness and lure of these sprawling inland
waters, the watchwork of the clouds sprung outwards
and uncoiling to the west? Now the water like choppy
dark blue grey ink, gunmetal gloaming, the horizon's
pale turquoise, and clay smudge behind, coming from
our smokestack. Now the vector thrust and length
of ship out into the lake—your smallness on deck
relative to it and the boat's smallness on the
inland sea. Feel the surge of power, as if the ship
is pushing the vast flood before it, engine throb
and hatches gleaming on the open main deck, low,
so long and heavy, smooth. Now you stand,
facing back, the chopped and murky waters
to the south, last roseate glow flung out behind,
and the marshalled heavens fanning into dusk.
Ahead the perfect line of delft blue darkening.
Chug chug of the motor thrusting through.
Purpose—you, part of the boat. A single
gull at rest on the antenna aft. Now with
the darkness the water's noises steal inside
you, looking out the porthole, the iron keel
beam of the prow veeing straight down, and the
displaced volume, yes, it must be exactly equal.
The boy's eyes glint like sparks, explaining this.
Each thing what it is. Haunted by the music
of the forward thrusting keel, its light shudder
and vibration, like being on some dock at sea,
we stationary, and the trackless current moving by.
Does the beam go down for miles? Now no recognizable
motion, no recognizable swell except in the heart,
taking on water, filling in a steady fill.
Another boat far off on the horizon—pure.
That too says, "far away—American dreamer."
Ahead the advancing darkness, behind the fading
twilight embers, and ripple of water alongside.
Now under winch housings, lights flickering on,
beneath the fo'c'sle one by one, around the aftercabins
and up the smokestack. Our boat—a signal.
First evening star above the Texas deck.
Onrushing darkness—split, separated.
Oh, wilderness campfires. You, in the middle, you.



Turning the corner

The four to eight watch allows you to turn the pages of the half days quickly and easily, always touching the coming or going light. They begin to fly through your hands. A new season brings new dangers and drives us closer together. Wind is bending round the corners of the boat in fierce whistles, cutting aeolian harps out of the wire rigging. Whenever water does not immediately flow down the scuppers or evaporate in the cold rush of air, an icy glaze will form. It was crackling off the metal cables a few minutes ago, as Bill and I worked the winches. Tom, the emperor, is wide-eyed and benign, almost soft spoken. You cannot trust him. It never lasts, an attempt to lure, to welcome us into winter's holocaust. We can complain now without having to take each other for the butt of our discontent, a querulousness, which is as much a part of the ship's progress as the engine's heavy throb and just as necessary.



Keep Moving

It's like a morgue in the Soo locks at 3 am.,
grandstands deserted, no newspapers in the rack,
cement walls frosting up as water level drops
and we descend into the crypt. It's always
hurry hurry here, respect for time and danger,
Mel moving at his little trot, I striding long
to keep up as we run the maze of gates and fences
for the mail. Then backwards down the sliding
ladder, quick step like dropping from the moon
glaring through the smoky haze above, cables
scraping round the edges, throwing sparks.
Putney passes the word as we hit the deck.
"Mr. Bellevue says not to hold hands
with the mate while he sorts the mail.
Get tarps on winches and put ropes away."
When we're done I cut back through the tunnel
listening to the twisting cries of metal
and water rushing by
my footsteps inside, countering
the river's flow
Motion—we belong to it.



Quickly

Unloading grain in Buffalo at Pillsbury elevator
in early January
walking toward the after deck
the second day of lay up
white snow on ice on everything
background pure all buildings purified
the breath sharp gulping air You live
it says expanding lungs
there the mauve white grey blue lavender
eye painful explosions of
criss crossing flocks of seagulls
scattering to the
rear of boat
in fear startle thunder whirr
catching pieces of everything blinding
the senses in one fanning whirl
all blues and greys and wings
their cutting shapes telling you
perceptions levels the world's there
and not there seen doubly triply in cross flashing
dazzle eye torture
nothing real that you had known—lifted
by this shattering of vision puzzle pieces
of sky snow and grain elevator
heaped on the air all sharpened
a crucifixion
the deep sight hunger rushing downward
connecting and driving out all you held familiar
light flashing off their wings'
painful pastels and that motion
everywhere and nowhere savage flutter
cross wheeling dissecting sky
the framework broken LSD birds
their flapping sound peeling layers
instinct's blind hunger everywhere
life swelling outward you stunned
light's shapes reacting deep within
the wing beat moment evanescent
breathless uncapturable
comment useless purged lifted
clean torn by their flying wedge
and riveted within the instant's vision
they settle almost as one thing a few late
dancers ease you down leave you picking up
reintegrating
all triggers pulled all doors blown open
in and out so fast
ringing on memory's primitive register
the eye crying it back knowing privilege
of beautiful things that are no more

Shadows and Stars

Pulling out of Conneaut tonight
the shadows from our working figures
loomed huge and substanceless
upon the fog. It was a quiet exit
and we quickly had the boat secured.
The town itself had tagged my memory
with the wet smell of decaying leaves,
a kind of desertion hovering
over even the shopping areas—
that sense of something fled.
There is a small cluster of taverns
on a hill just above the docks,
which is separate from the main town
and caters to the people from the boats.
When I left the first time to get
Joe Ross's beer, they were pinned
to their seats like stars,
Mel, Ron, and Eddie, talking
the bosun's ear off—
"You've seen me, how hard I work,
and I can do more . . ."
Tom's high nasal acknowledgement
somewhat preoccupied,
the money scattered up and down the bar.



The Great Lakes



Proton Decay

Kristin Blumberg

On a hot summer day, thousands of greater Clevelanders flock to Mentor Headlands Park on the shores of Lake Erie to swim and sun themselves and eat fried chicken from big bright-colored coolers. Most of them have no idea what goes on two thousand feet below where they've insinuated their backsides into the sand.

Two thousand feet below, workers from the nearby Morton Salt Fairport Mine have excavated miles of tunnels and removed tons of salt. That fact would seem remarkable enough to someone lying in the sun next to a massive body of water. But, even more remarkably, a group of scientists have transformed an unused part of the mine into a laboratory, in which an experiment of far-reaching significance is in its fifth year of operation.

Clyde B. ("Bud") Bratton, an experimental physicist from Cleveland State University who has been with the project since its beginning, likes to say jokingly that down at the bottom of a salt mine, in a strange but charming laboratory, scientists are searching for truth and beauty while up on top the ordinary public couldn't care less. The joke lies in the words *down and up*, *strange and charming*, *top and bottom*, and *truth and beauty*. These are the whimsical names physicists have given to the six quarks* which (along with leptons and gluons) form everything in the universe. The clues identify the project in the salt mine as a particle physics experiment, one in which scientists are trying to discover the nature and components of matter. Specifically, they want to know if protons, like the rest of us, have a finite lifetime.

It was once believed that the proton was immortal, but physicists since the thirties have questioned this assumption. Theories formulated to explain the proton's apparent stability were never quite satisfactory. Post-World War II experiments, using high-energy particle accelerators to scatter quantum particles for observation, discovered a virtual zoo of new particles, including lambdas, omegas, sigmas, and rhos. In the 1960s it was observed that protons, which along with many other particles are classed as hadrons (meaning "strong and heavy"), were made up of yet smaller particles: quarks. Protons were shown to be a composite of smaller pieces and it again became a significant question whether or not, in their natural state, protons broke down into those pieces.

The debate escalated further in the 1970s. Previously, proton decay had been one of many questions whose solution would add to the pool of general knowledge about matter. But



"My only exposure to physics was in high school, where we tinkered with pulleys, levers, and ideas that were on the cutting edge of physics two hundred years ago. But after working on this article, I found myself calculating how many years of school I would need to become an astrophysicist." Formerly an active participant in left-wing politics, Kristin Blumberg now works as a script writer at Cleveland State University, does odd jobs for Dobama Theater, and writes articles for Northern Ohio Live and Sun Newspapers. Blumberg attended Antioch College and graduated from Cleveland State University in 1984. She also writes short stories and is currently working on a play.

it attained greater relevance in 1974 when two physicists, Howard Georgi and Sheldon Lee Glashow, devised a theory called minimal SU (5) which seemed tantalizingly close to the Holy Grail of physics: a unified field theory—the master equation or law for all of material existence. Physicists, including Einstein, had been attempting to formulate such a theory for years. Specifically, the goal is to identify the four fundamental forces of nature as manifestations of one simple underlying force that has propelled the development of everything in the universe. The four forces are gravitation, electromagnetism, the strong force (100 times stronger than electromagnetism, it holds together atomic nuclei—in a nuclear reaction, it is the strong force which is unleashed), and the weak force, which produces certain types of radioactive decay. Unified field theories, also called grand unification theories (GUTs), attempt to unify electromagnetism and the weak and strong forces; so far, no one has been able to pull gravitation, the weakest force of nature, into any equation without qualification. Minimal SU (5) is the simplest and most convincing GUT. It asserts that at a certain tremendous energy threshold, the above-mentioned three forces become the same.

One problem with the GUTs is that they're almost untestable, as they are the product of exhaustingly complex mathematical equations about magnitudes of energy and time which are outside the range of observation or experiment. The one experimentally accessible factor of many GUTs is proton decay, which is predicted by most of the theories. Thus, the validity of these exciting new theories hinges upon the detection of proton decay. Without evidence of that, the theories hover in the realm of pure thought.

Even before the development of the GUTs, several scientists had seized upon proton decay as their own favorite conundrum. One of these scientists is Frederick Reines, who was a co-discoverer of the neutrino.* Reines had been working at the puzzle of proton decay since the 1950s. In the 1960s, Reines was head of the Physics Department at Case Western Reserve University and was involved in a series of neutrino detection experiments at Morton's Fairport salt mine. With the emergence of minimal SU (5), Reines, now at the University of California at Irvine, began planning for a new proton decay detector, along with physicists from the University of Michigan and Brookhaven. They secured Department of Energy funds for the construction of a very large proton decay detector, located just a tunnel away from the site of Reines's old experiment in the Fairport mine. The Irvine-Michigan-Brookhaven collaboration is known as the IMB project.

Proton decay, if it happens, does so very rarely and is difficult to detect. Instead of smashing quantum particles into each other with an accelerator, as physicists have done to separate and identify bits and pieces of the microcosm, they must create an observable space with the least possible quantum activity. The surface of the earth is constantly bombarded with tiny particles, muons and neutrinos, which are generated when the primary cosmic rays from deep space penetrate our atmosphere. Detecting proton decay on the earth's surface would be impossible because of this particle flux. So physicists

*There are three neutrinos. Each is an electrically neutral partner of the electron, the muon, and the tauon. All six of these particles are classified as leptons, meaning "swift and light."

conduct what are called low-background experiments, such as the proton decay project, deep underground where the earth's bulk inhibits interference from naturally occurring particle interactions.

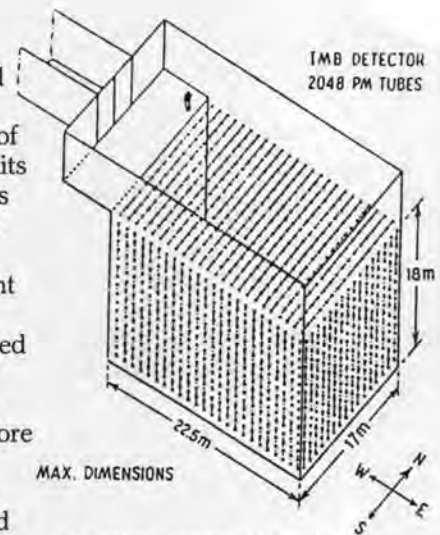
Salt mines are particularly well suited for low-background experiments because of the way they are engineered. At Fairport, as in many other mines, the "room and pillar" method is used: the salt is removed, leaving rooms that are forty to fifty-five feet wide, with ceilings eighteen feet high. Sturdy salt pillars are left for support. Such rooms, safe underground, have been proposed as storage for everything from oil reserves to government documents.

No salt mine, however, has a ready-made room large enough to house a proton detector. The Painesville project utilizes the water Cerenkov detector, a device based on the observations of Russian physicist Pavel Cerenkov who noted in 1934 that when a charged particle moves through water faster than light is able to move in water, it emits a tiny bit of light energy. When a proton decays, it is theorized that it splits into charged particles which dart away in opposite directions at the speed of light. The Cerenkov detector is an enormous rectangular box of water surrounded on all sides by 2048 highly sensitive photomultiplier tubes which react to the light from fast-moving charged particles.

The average proton's lifetime, although finite, is calculated by minimal SU (5) to be extremely long: approximately 10^{30} years (1,000,000,000,000,000,000,000,000,000,000.) The universe itself is only believed to be 10^{10} years old. To speak more precisely, 10^{30} is the half-life of the proton; this means that since protons decay randomly—some sooner, some later—in that period of time, half the given protons will decay. Instead of waiting 10^{30} years to monitor this process, a long vigil by any standards, scientists gather and scrutinize more than 10^{30} protons, that is, the number of protons in two and a half million gallons, or ten thousand tons, of water.* The Cerenkov detector is about the size of a six-story building. With that much matter, the physicists calculated they would observe proton decay about one hundred times a year.

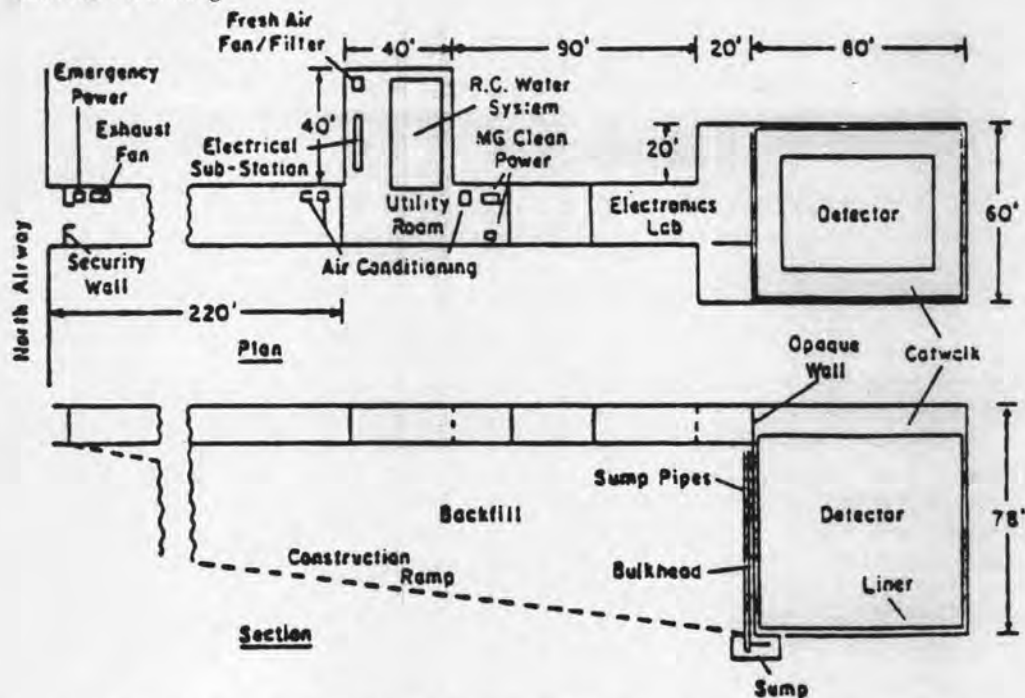
In 1979, Bud Bratton (who had already been involved with Reines and his Irvine colleagues in neutrino investigations) became involved and by 1980 the project was under way. The initial problem of locating such an immense space underground was solved when Morton Salt indicated that they wished to test a new continuous mining machine. Morton was willing to share the cost of getting the machine underground and would then excavate the required cavity, 65 x 80 x 60 feet, at cost. By September of 1981, the physicists began to fill the giant container with water. The experiment has been in full operation since July of 1982.

Bratton goes down into the mines three days a week. On a cold Monday morning in February, I went with him and Dan Sinclair, the other resident physicist on the project. Everyone who descends must wear protective gear: helmet and headlamp, steel-toed shoes, and an emergency breathing apparatus. The 2000-foot trip down takes four minutes. The elevator, a steel cage, is cold and dripping and as it approaches the



Cerenkov detector: Schematic view of detector from top. Each dot represents one of 2048 PMT's arranged on all six walls.

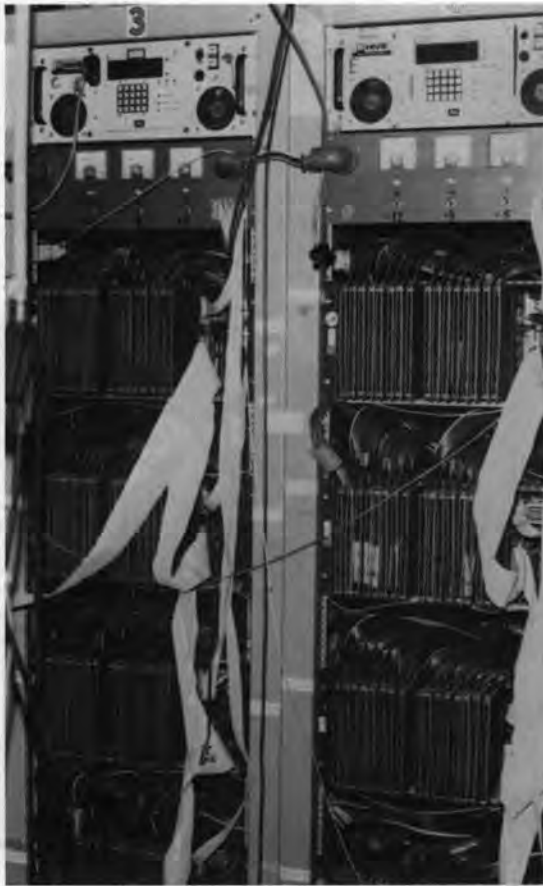
*The experiment actually monitors more than this: 10^{33} protons, which is the experimental limit of the project, as a larger amount of water would pick up too much interference from neutrinos passing through the earth.



Overall view of Proton Decay Laboratory.

bottom, the noise from a huge fan at the base of the shaft, which draws fresh air into the mine, is deafening. As we left the elevator, I realized that the headlamps are not just picturesque; as we walked away from the moderately-lit shaft area into dark tunnels, the small beams from the headlamps were our only illumination. I was quite careful to keep up with Bratton and the others, but the darkness doesn't last long. In a better-lit tunnel, the walls of the mines are visible, marbled with condensation which builds up in the humid summer months, causing salt in the walls to "bloom" into coral-like formations. On the floor, the powdered salt looked like flour and made it hard for me to hear the sound of my own feet. Past the steel door of the IMB project, though, things are quite different.

Inside the laboratory, it is easier to forget that 2000 feet of our planet are overhead. The floors are concrete, the light is bright, the air is conditioned, and the walls are stuck in odd places with cartoons, a poem, and several health and safety admonitions. The first room is full of the filtering equipment required to transform city water into the pure stuff needed by the detector. The next room has tables and chairs, a refrigerator and hot water machine for instant coffee and tea, and at the end of the room, walls of wires and lights that correspond to the photomultiplier tubes (PMTs) in the detector. There are two computers that record events (i.e., when the PMTs register something) and perform some preliminary weeding out of unacceptable events. The succession of events is sent to Irvine and Michigan for analysis. In the next room, the door to the detector stays shut. Hanging just outside is an inflatable plastic shark. The physicists leave the detector dark and undisturbed, as any ordinary light causes the highly sensitive PMTs to misbehave. Once every three weeks, divers from the University of Michigan Engineering School's department of underwater technology go into the tank to inspect and clean. There are twenty-nine scientists from nine institutions involved in the project, but only seven or eight go to the mine regularly.



Technician Bob Render repairs the high voltage power supplies.

Power supplies—high voltage at top of picture, low voltage below. High voltage powers the electronics that digitize the information from the photo-multiplier tubes; low voltage provides power for signal feedback.

Even though the experiment is underground, extraneous particles still fly through, setting off the PMTs. About three muons enter the detector per second, which is $1/10,000$ of their surface rate. While the muons are merely a nuisance (they don't really "look" like proton decay), neutrinos, which pass through the earth's mass unhindered, are a much bigger problem. Neutrinos can strike the detector in the exact energy range of proton decay. Although this possibility is only theoretically predicted once every two or three years, in such a long, patient process as this experiment such an event can be trouble.

Bratton explains the process for screening out irrelevant particle events: "The computers are set up to reject events for certain reasons. One of the main cuts, as we call them, is based on the number of tubes that light up. If the number of tubes is too small, then that's probably just noise. If too many tubes light up, 99 times out of 100 it's because of a muon. We know that proton decay will only light up a certain number of tubes, within a certain range. Muons come through, light up too many tubes, and the computer says, 'Don't bother.' On the other hand, you do get muons that whip through the corner of the detector, light up fewer tubes—in the proton decay range—and that's recorded. Then the analysis folks have to look at the pattern and say, 'Yeah, that's a corner clipper.' The neutrino background can really interfere with the experiment. They cause events that could be interpreted as proton decay, but they usually don't do it in the right energy range. The theoretical prediction was that we'd see a neutrino event that would be the perfect duplicate of proton decay once every two-three years."

So far, in the project's four years of live time (there has been some down time), not one incident of proton decay has been observed. There have been promising candidates but no absolutely positive "gold-plated" events. Despite all the eyes watching this project, the lack of results doesn't seem to upset Bratton. "The lack of verification," he says, "has effectively killed off the minimal SU (5) theory, but that really doesn't stop the other theoreticians. There are almost as many grand unification theories as there are theoreticians, all of them tweaking their own set of parameters. Of course, this sounds like an experimentalist talking. The trouble with all the theories is that they have too many parameters to be wiggled around. If they adjust the theory and take the proton lifetime to 10^{40} , it's way out of reach experimentally. One of the ways of distinguishing between mathematics and physics is that the mathematicians quit when they reach their proof. Physicists can write all the math they want, but no one believes it has any bearing on the real world until it's experimentally proven."

Any disappointment in the elusiveness of proton decay has been dwarfed by an unexpected and exciting development for the IMB project. The scientists had realized all along that their detector might have some incidental use as a sort of cosmic register, picking up subnuclear splatterings from deep space. In mid-March, the IMB project announced it had recorded a neutrino burst from the supernova discovered February 24, 1987 in the Large Magellanic Cloud, 160,000 light-years away. A supernova this bright (it was visible to the naked eye in the earth's southern hemisphere) has not been seen in our galaxy since 1604.

After blazing for billions of years, a star exhausts its nuclear fuel. Very big stars, once they have finished their final stage of burning, collapse from the gravitational pressure of their huge mass. The result is a tremendous explosion, as bright as billions of suns, where new elements are created in the extreme heat and pressure and then are blown, along with the star's outer layers, into space. The remaining core becomes a neutron star, incredibly dense, where a cubic inch of matter weighs billions of tons.

Until recently, all these ideas about supernovas and neutron stars, along with other ideas about stellar evolution, were speculation, based upon theories, mathematical models, and computer-generated agendas of development. After all, no one had been able to study a supernova for almost four hundred years. But the new supernova and especially the data recorded by the IMB project, along with the proton decay detectors in Japan and in the Mont Blanc tunnel on the French-Italian border, support many of the new ideas. The theoreticians had predicted that when certain stars collapse they would release neutrino bursts, created by nuclear reactions in the core. The IMB detector registered a burst of eight neutrinos in six seconds on February 23, before the visual sighting was made. That six-second episode made world news.

"When you figure we normally get one neutrino event per day from the atmospheric neutrino flux," says Bratton, "then you can understand how big this is. These neutrinos actually came from outside our solar system. This is the first time



Two carbon filter tanks (foreground) and two depth tanks. They are used to filter "city water" before it is softened and run through the reverse-osmosis-membrane system to produce ultra-pure water for the detector.

we've ever seen extra-terrestrial neutrinos, as opposed to atmospheric neutrinos [those caused when primary cosmic rays from deep space pass through our atmosphere]. We've only had that one six-second burst. The theoretical people say as this goes on we should see more. And like the good folks we are, we'll keep on looking."

Even without the supernova excitement, the future of the IMB experiment doesn't seem to be threatened. Depending on funding and interest, it could go on another two to three years. At the very least, physicists are learning that the lifetime of the proton is longer than anyone had anticipated. Even if proton decay doesn't make some of the fancier new theories work, the project provides new knowledge about the fundamental stuff of the universe. Bratton says, "It's good old basic research. Like they say, you do it because it's there. Someone asks a question and you try to answer it. You never know what the consequences will be. If people had set out to invent solid state chips as we know them today, they probably never would have."

The proton decay project also relates to other esoteric pursuits of physics, specifically the quest to understand the very beginning of the universe, the first microseconds of the Big Bang. One of the questions physicists have about the very early universe is how the matter that makes up our world survived the Big Bang. It is believed that the universe is a symmetrical place; just as the positive and negative particles are balanced to yield an electrically neutral universe, matter and anti-matter should be equally balanced. If this were so, by an annihilation process, matter and anti-matter should have combined, in equal parts, to yield nothing. This is obviously not so. However, if the proton is proved to have a finite lifetime, it will indicate that the amount of matter in the universe—traditionally believed to be a fixed and unchanging quantity—can change. It can perhaps shed light on how, in the early universe, an excess of matter was created, and whether matter will ultimately disintegrate into nothingness.

"The idea of the grand unification theory is that quarks can change into leptons and vice-versa," says Bratton. "One of the problems of this universe is that it seems to be populated with more matter than anti-matter. You have to try to understand how it got that way, because, if in the beginning there was good total symmetry, any production of particles should have been accompanied by anti-particles. With the resulting annihilation process, there should be equal amounts of anti-matter. But this is why you get science 'friction' stories about an anti-universe or an anti-earth on the other side of the sun that none of us see. When all is said and done, there is an excess of matter. Proton decay could solve the thinking along these lines."

Given all this, nothing you can imagine, be it wraith or visions of sugarplums, sounds any more fantastic than the explanations that theoretical physicists invent. But the pursuers of proton decay never forget the vital link between theory and evidence. Stuck to the exit of the Morton laboratory is a message, a plastic strip of bumper sticker profundity, which declares, "Nothing is Forever." Underneath, a marked scrawl replies, "Prove it!" ■

Recommended Reading

Pagels, Heinz R. *Perfect Symmetry: The Search of the Beginning of Time*. Bantam Books: New York, 1986.

Zukav, Gary. *The Dancing Wu Li Masters*. Wm. Morrow & Co.: New York, 1979.

The Great Lakes



Lake Ontario's Time Capsule

Emily Cain

On August 8, 1813, HAMILTON and SCOURGE, two American armed merchant schooners capsized in a squall on Lake Ontario. They now lie in three hundred feet of water, six miles off Port Dalhousie, Ontario, intact, with all their artifacts, perfectly preserved in the darkness and near-freezing temperatures of the fresh lake water. Guns sit on their decks, with equipment nearby; pikes, boarding axes and cutlasses are ready for the hands of the sailors. It is as if they could sail along the bottom of the lake, under a cloud of canvas to some watery underworld. They are the best-preserved wrecks of historical significance in the world: they provide blueprints of naval practice of the time; they are among the first generation of merchant vessels to ply the lakes; they provide a unique window on the lives of our earliest settlers.

HAMILTON is the pre-war DIANA, constructed at Oswego, New York, in 1809. Her regular run was Oswego to Lewiston, at the base of the American portage around Niagara Falls; the greatest part of her cargo was salt from the factories at Salina (near today's Syracuse), but she also carried luxury goods shipped from the great wharves of New York up the Hudson/Mohawk waterway.

She is armed with 8 eighteen-pounder carronades (short light cannon), and one center-mounted twelve-pounder long

Emily Cain is "delighted to be an American in Canada working on a Canadian project so deeply related to the United States." Her position as research and coordinating officer for the Hamilton-Scourge Project is a continuation of an early interest in ships and shipbuilding. As a child in Ipswich, Massachusetts, she lived next door to one shipyard and within sailing distance of another. Cain earned a B.A. from Radcliffe University and an M.F.A. from Yale University, and holds certificates in business management and museum studies. She is the author of a book, Ghost Ships, Hamilton and Scourge (1983).



"Diana" the Huntress graces the bow of the American armed schooner HAMILTON, sunk by a storm during the War of 1812. The schooner lies 80 m deep, 10 km out from St. Catharines, Ontario, near the watery grave of her fellow schooner SCOURGE, lost the same night awaiting battle with the British fleet. DIANA was the ship's original name before she was bought and refitted as an American warship.

National Geographic Photo
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Foundation



SCOURGE's figurehead depicts a lively merchant of the 1812 period. The vessel, originally named LORD NELSON, was constructed at Niagara, Upper Canada, in 1810-1811 for William Crooks and his brother James (who was a great landowner in the province). She was captured by the American brig ONEIDA for suspicion of smuggling thirteen days before the War of 1812 was declared. Taken to Sackets Harbor, New York, she was refitted and renamed SCOURGE.

National Geographic Photo
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gun. Behind the schooner lies her ship's boat, a seventeen-footer designed to be sailed as well as rowed. She has two anchors, with wooden stocks, and sweeps (long oars). Painted black, she is graced with a beautifully carved bust figurehead depicting the goddess Diana, who on her right side wears an Empire dress, and on the left only a quiver full of arrows.

SCOURGE was originally LORD NELSON, built at Niagara (now Niagara-on-the-Lake), Upper Canada, in 1810-11 for the Scottish merchant brothers, James and William Crooks. Her regular run was from Niagara to Prescott on the St. Lawrence; she almost certainly carried flour from William Crooks's mill at Forty Mile Creek (now Grimsby, Ontario) to Prescott, with other products of the wilderness, such as staves and furs; bills of lading indicate that, on the return trip, she carried china, glass, personal effects, bar iron, cast iron, and other manufactured items forwarded from Great Britain via Montreal.

The LORD NELSON, suspected of carrying smuggled goods, was captured by the enterprising Melancthon T. Woolsey, USN, in the U.S. Brig ONEIDA, on June 5, 1812, thirteen days before the War of 1812 was declared by the United States. This pre-war capture provoked a lawsuit which was finally settled through an international treaty court; payment was made to the original owners' descendants in 1930. After the capture, she was taken back to Sackets Harbor and armed.

SCOURGE's figurehead depicts a striding merchant, wearing business clothes, Hessian boots, and a sailorly queue. The ship is armed with 10 four- and six-pounder long guns on trucks, and on her deck are pikes, and a rack of boarding axes; cutlasses are close at hand. She also has a full complement of sweeps.

Both schooners have raised quarter decks to give headroom in the aft cabin. The lake schooners had a reputation for comfortable accommodation: Niagara Falls was then, as now, a great North American tourist attraction.

Both LORD NELSON and DIANA were purchased by the United States Navy in 1812 and renamed SCOURGE and HAMILTON. HAMILTON was part of the United States naval force which attacked Kingston in November, 1812; both schooners were used in the American attack on York in April,



One of SCOURGE's ten 4- and 6-pounder long guns on trucks peers from its station, just as on the night of August 8, 1813, when the ship went down in a Lake Ontario squall. SCOURGE's fellow schooner HAMILTON, which capsized the same night, is armed with eight carronades on slides, and a large central-mounted pivot gun.

National Geographic Photo
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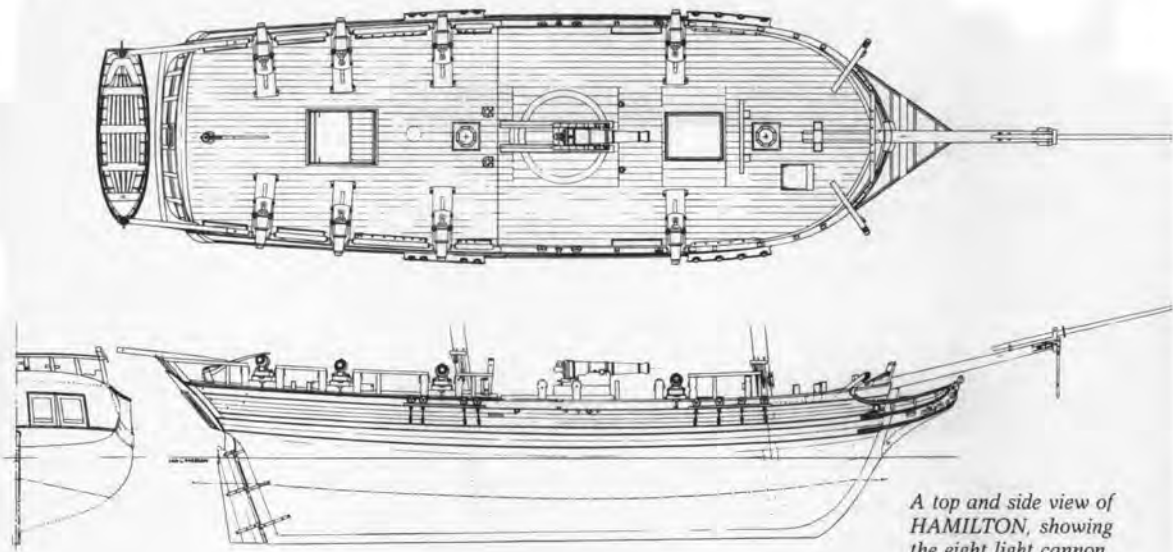
1813, and on Fort George in May of the same year. They both capsized in a squall on August 8; fifty-three men died in this combined catastrophe; there were eighteen survivors.

One of SCOURGE's surviving sailors was Ned Myers, who had been a shipmate of James Fenimore Cooper; Cooper published Myers's autobiography in 1843. The book was immensely popular, went into many editions, and was translated into both French and German. Myers exactly describes his service in SCOURGE, and gives a detailed account of her sinking:

Our decks seemed on fire, and yet I could see nothing. I heard no hail, no order, no call; but the schooner was filled with the shrieks and cries of the men to leeward, who were lying jammed under the guns, shot-boxes, shot, and other heavy things that had gone down as the vessel fell over . . . I crawled aft, on the upper side of the bulwarks, amid a most awful and infernal din of thunder, and shrieks, and dazzling flashes of lightning; the wind blowing all the while like a tornado . . . The water was pouring down the cabin companion-way like a sluice, and as I stood for an instant on the fashion-piece, I saw . . . [our captain], with his head and part of his shoulders through one of the cabin windows, struggling to get out. He must have been within six feet of me. I saw him but a moment, by means of a flash of lightning, and I think he must have seen me . . . It now came across me that if the schooner should right she was filled, and must go down, and that she might carry me with her in the suction. I made a spring, therefore, and fell into the water several feet from the place where I had stood. It is my opinion that the schooner sank as I left her.

Myers then took SCOURGE's boat, and saved himself and as many of his shipmates as he could find. His account and the log of the Royal Navy flagship WOLFE were the two documents which proved most valuable in the search for the schooners. The search, initiated in 1971, was led by Dr. Daniel Nelson, a dentist from St. Catharine, Ontario, through the Royal Ontario Museum with the aid of Canada Centre for Inland Waters, of Burlington, Ontario. The schooners were discovered in 1973, and the discovery was confirmed in 1975. At that time, a videotape of HAMILTON taken by means of a prototype remote-operated vehicle indicated that the schooners were in a remarkable state of preservation—timbers square "as if cut yesterday."

HAMILTON was viewed by the Cousteau team in 1980. In the same year, title was transferred from the United States Navy through the United States Congress, and the Royal Ontario Museum, to the City of Hamilton; enabling legislation was passed by the Provincial parliament. A HAMILTON-SCOURGE Foundation-National Geographic Society survey of both schooners was conducted in 1982. Historical research connected with these ships has brought to light a fascinating picture of life around the Great Lakes in the early nineteenth century. Records and anecdotes reveal a great amount of smuggling activity during this period. The lakes' merchants, disregarding official regulations, sensibly treated the area as an economic whole, and American schooners traded—sometimes entirely—on the Canadian shore (e.g., SENECA), and vice versa (EAGLE). Ships owned by Upper Canadians were sailed



A top and side view of HAMILTON, showing the eight light cannon and the center-mounted long gun.

National Geographic Photo
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by Americans (e.g., LORD NELSON) and sailors were employed without regard to nationality (all vessels). Customs agents were perplexed about enforcing the laws (see especially the Joel Burt papers, Penfield Library, SUNY at Oswego); and sometimes simply gave up. The sons of SCOURGE's shipwright, Asa Stannard, moved to Cleveland, where they were involved in upper lakes shipping. Material relating to them in the Western Reserve Historical Society archives has been and will continue to be fruitful as the HAMILTON-SCOURGE Project develops in the next few years.

In 1986, a HAMILTON-SCOURGE Steering Committee was formed, with representation from the three levels of government, to set policy for, and oversee the work of, a Feasibility Study Team, whose responsibility it is to present, by 1989, recommendations for the project's future as a major museum display.

Meanwhile, during the summer months, the Project operates a small Interpretive Centre at the future museum site at Confederation Park in Hamilton (northernmost point on Highway 20), at which scholars and tourists from all over the world are welcome. Here is also a War of 1812 Naval Memorial Garden, where on a replica of SCOURGE's foremast fly the Union Jack, Canadian Maple Leaf, and the true fifteen-star, fifteen-stripe Star-Spangled Banner. Fifty-three markers modeled after those at Arlington and in Allied cemeteries around the world commemorate the HAMILTON and SCOURGE sailors who lost their lives nearly 175 years ago. Beside each stone lie bronze memorial plaques given by the National Society, United States Daughters of 1812, which identify the sailors as veterans of this conflict.

Marine museums all over the world look enviously at HAMILTON and SCOURGE, and watch with great interest the progress of this international project which is connected to the beginnings of the two North American powers. They are time capsules—fascinating resources for those who live beside the Great Lakes. ■

The Great Lakes



The Making of Lake Erie

Thomas Lewis

If Lake Erie's shoreline today resembled what it was some 13,000 years ago, a visitor to Cleveland would find most of downtown under water.* Icebergs might be seen dotting the lake. To the west, Bowling Green would be a small peninsula barely a few feet above water. Toledo couldn't exist except on stilts. A car trip from Cleveland along the shore to Ann Arbor then north to the base of Michigan's thumb would be a lengthy affair, but perhaps worth the effort in order to view the violent discharge of waters from the lake outlet of the Grand River Valley on their way to Lake Chicago occupying the southern Michigan basin. Trips to any other of the Great Lakes would require snowmobiles to traverse the glaciers filling them. To the east, the lake shore would not be much different, but would follow a path close to the high cliffs of the Allegheny plateau and extend nearly to Buffalo where ice blocked the eastern Erie basin.

This period, part of the brief proglacial [beyond the edge of an ice sheet] lake history when the last glaciers were retreating northward, was the result of the latest of multiple glaciers that helped gouge and refine the lake basins over the last 1.5-1.8 million years. The positions of the Great Lakes (whose history is much older than that of the glaciers) and parts of their basin geometries can be traced to cyclic stream erosion cutting the underlying rocks along structural weaknesses related to very ancient events. For example, Lake Ontario follows an east-west zone of easily eroded rocks between more resistant layers that tilt southward off the ancient Canadian shield. Lake Huron, Georgian Bay, The Mackinac Straits, and Lake Michigan follow weaker rocks structurally shaped in a circular basin (like a series of stacked saucers decreasing in size upward). This Michigan basin slowly subsided as marine sediment accumulations were deposited in this area between 500 to 280 million years ago. The linear trend and sunken parts of the Ottawa-St. Lawrence lowland may be related to 100-million-year-old rifting events in the earth's crust. The deep linear western arm of Lake

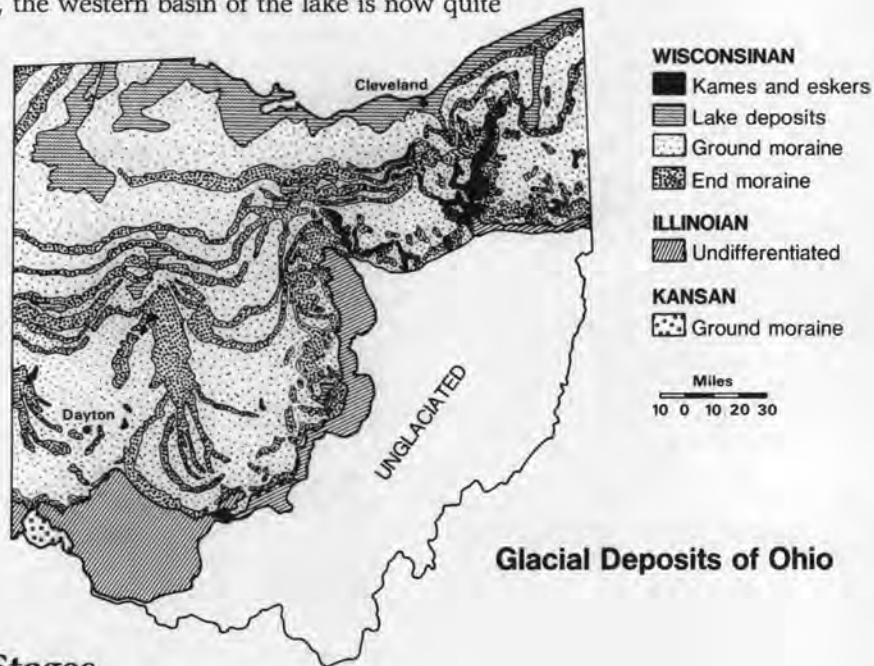


A professor of geology at Cleveland State University, Thomas L. Lewis was born in Rochester, New York, and has always lived on or near the Great Lakes. He received his B.A. from Oberlin College, his M.S. from the University of Rochester and his Ph.D. from Ohio State University. Lewis has frequently lectured on the geologic origin of the Lakes at science seminars, as well as at the Great Lakes Historical Society and the North American Society for Oceanic History. His specific area of interest is the sedimentology of the Great Lakes, particularly in the Erie and Ontario basins, and he has published a number of articles in journals such as Rock Products, Journal of Geology, and Journal of Sedimentary Petrology.

Superior is, in part, a natural synclinal basin (that is, one in which the rock strata slant inwards from both sides towards the axis of a fold) started by ancient rifting and folding, which was filled in by sediments and volcanic effusions over a billion years old.

Only Lake Erie extends athwart the structural dip of the rocks, choosing to follow, in its eastern and central basins, the northeast-southwest axis of an ancient marine sea. (What seems to be one lake may be, as in the case of Lake Erie, a set of interconnected depressions, or basins, of varying sizes and types, the whole constituting the Lake Erie basin.) To the west, the axis of this ancient sea turns southward, and so became the path for major ice intrusions into southern Ohio (Figure 1). Ice did extend westward, but had difficulty eroding hard limestone bedrock at right angles to the structural dip and bedding weaknesses. Hence, the western basin of the lake is now quite shallow.

Figure 1
Glacial Deposits of Ohio. Modified from an adaptation of the Glacial Map of Ohio, U.S. Geol. Survey Misc. Geol. Investigation Map 1-316.



The Glacial Stages

Glaciation on a large scale is recorded only a few times over the last several billions of years but "our era" is an unusual one from a geological perspective. In the last 1.8 million years, the northern hemisphere has been subjected to numerous glacial episodes, four of which have been recorded in the landscape of the Great Lakes. Perhaps we are now experiencing an interglacial age, as we enjoy a mild climate that in geological terms may be only momentary.

Of course the present world is hardly ice free—witness the Greenland and Antarctic ice sheets as well as the Arctic pack ice and numerous valley glaciers of the high elevations and latitudes. The volume of the globe's ice cover now amounts to thirty-three million cubic kilometers—about one-third the amount that covered the earth during each of the major glacial stages.

Glaciers are, in part, oceans temporarily locked up on land. They represent a disruption of the hydrologic cycle, in which evaporated water, originating mostly from oceans, is

discharged on continents and normally returned to the oceans by streams, glaciers, groundwater, evaporation, and transpiration. During times of glaciation, when the oceans were feeding the glaciers, sea levels fell as much as 450 feet, exposing vast areas of the continental shelves. Subsequent sea-level rises, during interglacial periods again flood continental margins. One should not be surprised that sea levels are still rising as part of the last cycle, or that a great acceleration of that rising is forecast as a result of the "greenhouse effect" of global warming and consequent melting of residual ice masses.

Glaciation spread from a center in arctic Canada, notably in the Labrador and Hudson Bay regions, although there were probably many small centers that eventually coalesced into major ice sheets. Ice moved laterally in all directions, but the major expansion occurred southward since moist air masses continued to move in from the south and west (as they do today), dropping snow and feeding the margins of the ice sheet. Enlarging by accretion, an ice sheet moved south and southwestward into the Great Lakes region, sometimes extending well south of this area before its advance was halted as melting exceeded accumulation. Major ice sheets also moved eastward across the presently submerged continental shelf, their advance controlled by the rates of "calving"—the breaking off of icebergs that drifted southward to destruction in warmer waters. Cold summers in the north with mostly freezing conditions were probably necessary to maintain much of the glacial ice, although mean annual temperatures in areas marginal to the ice may have only been a few degrees (Centigrade) lower than present.

The southward trek of the glaciers proceeded, not as a straight wall of ice, but as a series of lobes, like large stubby fingers. They probed, followed, and enlarged valleys originally created by stream erosion along weak regional zones in the ancient rocks, but they were also thick enough to expand over large areas of high ground as well. The ice expanded and diminished, modified by global episodic events as well as more random local climatic effects. At least four major ice ages (the Pleistocene Stages), each represented by several retreats and advances along with interglacial soil zones, are recognized in the Great Lakes area. Each successive glacier partially destroyed or covered previous deposits so the record of events is incomplete and unevenly distributed throughout the area. The youngest glacier (Wisconsin Stage), therefore, provides the most complete record, beginning about 70,000 years ago; after several advances and retreats, it began to withdraw from the Lake Erie basin about 14,500 years ago.

The glaciers were powerful eroding agents, plowing up the countryside with ease, grinding, scouring, polishing ancient bedrock, and moving the debris elsewhere to be deposited as loose and poorly sorted glacial tills when the ice melted. Some of the tills are large and form into extensive bow-shaped arcs or moraines, as a result of dumping at the margins of stubby lobes during ice stagnation. In-between areas are marked by ground moraines that plaster the bedrock surfaces, isolated small lakes, and peat deposits. Meltwater streams from the glaciers' edges have selectively sorted some debris into distinctive deposits of sand and gravel. Glacial landscapes are often

dotted with large isolated boulders of colorful igneous and metamorphic rocks carried south from Canada. These so-called "erratics" are distinctly dissimilar from the local ancient marine bedrock. In the Cleveland region, occasional erratics from a very ancient glacial deposit can be found. This two-billion-year-old glacial till (Gowganda Tillite, north of Lake Huron shores), records scratches and grooves tooled on it during a recent Wisconsin ice event, some of it subsequently pushed south by the same ice advance.

It is likely that Ohio's ice locally came from the Ontario Basin and the southern outflow from the Province of Ontario. The Erie basin itself may have been a center of gathering snow that accumulated faster than could be melted in the summer and therefore acted as a local center of thickened ice. Estimates suggest that ice was more than three-quarters of a mile thick over the Erie basin.

Initial Wisconsin ice moved into the Ontario-Erie basin about 40,000 years ago. It advanced into northeastern Ohio 60-70 miles inland south of the present lake shore. It crossed over the northern Allegheny plateau and deposited extensive mounds of gravel before its retreat. A second advance (30,000-40,000 years ago) brought finger-like lobes through the Grand River and Cuyahoga River valleys as well as a more expansive lobe (Killbuck) across the northwest projection of the plateau in Ashland and Richmond Counties.

This Wisconsin substage was followed by an interval of warming, soil formation, and erosion lasting until about 23,000 years ago. During this time, several large lakes may have



Figure 2
Map of Great Lakes indicating extent of ancient lake plain deposits, various outlets and their major direction of flow. Modified from Fig. 3-2 Glacial Geology of the Great Lakes Basin, Great Lakes Basin Framework Study, Appendix 3, p. 94.

existed long enough to produce cliffs and terraces marginal to southern shores (along which several younger post-glacial beaches were subsequently superimposed). Ice returned to Ohio for the third time with lobes once again squeezing into the already established drainage areas. Two other expansive lobes, finding easy access parallel to the weak, ancient marine shales exposed west of the escarpment of the Allegheny plateau, penetrated far into the Scioto and Miami drainage basins of central and southern Ohio (Figure 1). They reached their southernmost limits well past Dayton about 18,000 years ago for the Scioto lobe and 19,500 years ago for the Miami.

The disappearance of the last thinning ice sheets from Ohio took place over approximately 5000 years. During times of ice stagnation, moraines developed (Figure 1). Some of these—the trains of hummocky hills of present-day central and western Ohio—were quickly formed perhaps from dirty ice, or re-formed from thick, underlying veneers of dirt. Also, vast quantities of sand from meltwater streams stretched southward from valleys in many areas. Occasionally small lakes developed on the ice margin during the retreat and left thin layers of fine-grained muds interrupted by sandy delta deposits. These also occur in the Erie basin area and represent small precursors to the main post-glacial lake events. By 14,500 years ago ice was mostly gone from Ohio, thus allowing initiation of the main lake stages.

Lake Basin History

When glaciers melt, they leave behind holes in the earth, some now filled with lakes. At present Lake Erie waters cover about one-third of the entire basin, but lake deposits show that formerly, water filled half and perhaps two-thirds of the entire basin (Figures 1, 3). These lake plain deposits constitute a discontinuous record of lake events. Beach and shallow water bar deposits, deltaic sands and gravels, deeper water muds, even some wind-blown sands: the lateral and vertical juxtaposition of these units in sequence helps determine the relative order of the formative events. The deposits which occur below present lake levels also preserve part of the historical record. Radiocarbon dates of buried plant remains and preserved shell fragments help set absolute dates in the history of the lake.

The history of glacial and post-glacial lakes is complicated for a variety of reasons. Proglacial lakes were often raised and lowered by repeated glacial retreats and readvances. Thick, heavy ice sheets compressed land surfaces for long periods. After the ice was removed these land surfaces rose in what is called isostatic rebound*, which was often uneven so lands might rise at one end of the basin (often northward where the ice had been thicker and the area more recently covered) while other parts of the basin became submerged. With continuing deglaciation, new discharge channels, often running parallel to ice margins, would cut through lowered surfaces and water would cascade via these new routes to still lower basins (Figure 2). Isostatic rebound, rapid at first, raised the new channels and slowed their flow, allowing lake waters to rise. Sometimes old drainage outlets reopened to discharge these rising waters. Finally, smaller-scaled fluctuations due to climatic change helped control levels.

*the ground uplift after the removal of the ice's great weight

The proglacial history of the Erie basin lasted about 1900 years starting 14,500 years ago. Its record is represented locally by beach ridges and deposits of gravels and sands spread on plains along the southern and western margins of the basin. These mark temporarily stable positions when the diminishing of the water was interrupted by the return of the ice still present in the eastern part of the basin and to the north in the Huron basin.

The main lake event began in northeast Ohio and northwestern Indiana when meltwater was trapped between the fluctuating Erie and Huron ice lobes and higher land elevations to the south (Figure 3). Three lake levels are recorded for glacial Lake Maumee as it adjusted to outlet channels. Drainage was southerly, to Fort Wayne; when deglaciation and lake expansion took place, a new outlet opened at Imlay, Michigan; when the Imlay outlet rebounded, the southern outlet took over. Retreating ice produced several north-south, arc-shaped moraines across the basin, as well as the Ashtabula moraine parallel to the shore east of Cleveland (Figure 3).

The ice continued to retreat in the northwest Erie and southern Huron basins, and a lower channel outlet was opened at Ubyly, Michigan (Figures 1, 3). Waters in the Erie basin dropped, periodically stabilizing to form three levels of glacial Lake Arkona. The Ubyly outlet closed during a possible low-level stage, but was reactivated when water rose above the former Arkona levels, and a pronounced shoreline was created at 740 feet by glacial Lake Whittlesey. The Whittlesey event occurred about 13,250 years ago and lasted for perhaps 200 years.

Lake Whittlesey gave way to a shallower glacial Lake Warren, created in response to the lowering of the Ubyly channel and to climatic fluctuations. A brief interruption of this sequence occurred, caused by a lower lake (glacial Lake Wayne), which initially drained eastward but was closed off by returning ice. Lake levels dropped from the time of the last Warren level, adjusting again to the western discharge route; only poorly preserved beach strands and sand patches record glacial Lakes Grassmere and Lundy.

Waters in the Erie basin reached perhaps their lowest level around 12,500 years ago with the deglaciation of the Niagara valley and subsequent rapid channel incisement down to bedrock near Buffalo. This bedrock sill, depressed as much as 130 feet below present lake level, opened a violently cascading outflow that spilled northward across the Niagara escarpment to the deglaciating Ontario basin.

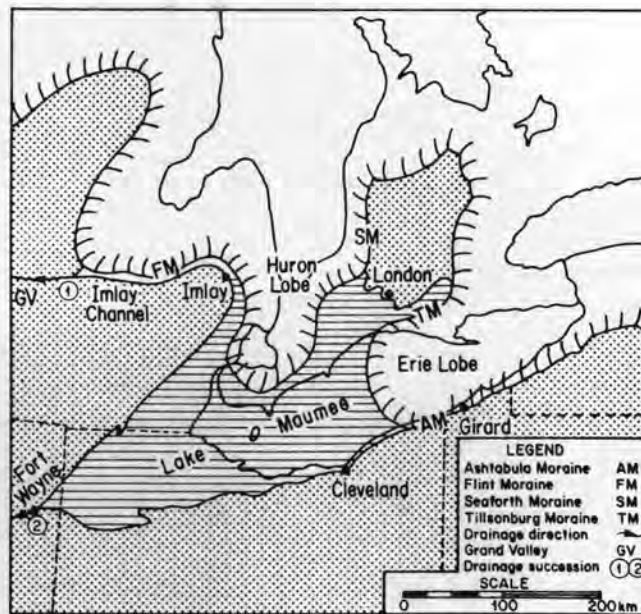


Figure 3
Map of Middle Lake Maumee, an early glacial lake. (From Calkin and Feenstra, 1985, p. 152.) Drainage of Maumee phases varied from positions at Fort Wayne (southwest) and westward through the Imlay channel to the glacial Grand River valley. Also, periodic stagnation of the retreating Erie lobe, allowed development of several north-south arcuate-shaped moraines (not shown) across the bottom of the basin.

The rising of Lake Erie's waters is thought to have been rapid between 12,000-10,000 years ago. It slowed between 10,000 to 7000 years ago perhaps because of downcutting of the outlet, influence of drier climates, or the direct eastward drainage of Algonquin from the Huron basin (as noted above). A slow rise ensued until it reached a height of fourteen feet below the present Lake Erie level where it remained for nearly 2000 years. An abrupt rise occurred between 5000 and 3900 years ago to about sixteen feet above the present level at a time when drainage from the Huron basin was re-established through Port Huron. The level dropped to the minus sixteen-foot position again by 3000 years ago, perhaps as a result of adjustment to increased flows from the Huron basin. The lake has slowly risen (about twenty feet) to its present level over the last 3000 years.

The Future of the Basin

At present, the lake levels have reached a reasonable equilibrium, dropping and rising in predictable cycles and in response to unpredictable meteorological events. Although some glacial rebound continues in diminished amounts, the outlets seem stable. The geological stillness—the adjustment to isostatic equilibrium—lends some sense of calm to developing events, but the stillness may be more apparent than real.

The long-term future, measured in a few millennia, is likely to be one of destruction and regeneration. Another glacial cycle may be ready to occur, on the basis of a long historical record of multiple glaciation. There seems little doubt that the glaciers will return, continuing a nearly forty-million-year cooling of the northern hemisphere. Evidence pointing toward continuing glaciation includes pronounced northern exposure of the continents, a land-locked ocean restricting the intrusion of warm water currents, and the recurring Milankovich cycles. These cycles, up to 100,000 years long and caused by variations in the earth's orbit and the angle and wobble of earth's axis, influence insulation and the earth's heat budget. Glaciation may also be influenced by the lowering of earth's reflectivity to solar radiation through exposure of more rocks or land surfaces (compared to water or ice), and reduction of ice reflection due to increased dirt outfall. Dust accumulations may increase cloud formation, a further cooling mechanism.

On the other hand, a warming influence must be reduced if glaciers are to re-occur. The atmosphere is transparent to incoming visible light but the atmospheric gases carbon dioxide, ozone, and water vapor help block the longer wavelength heat energy re-radiated from earth. This "greenhouse effect" is well established, but much more must be known before accurate predictions of this warming trend can be determined.

A new glacial advance would efficiently sweep sediments, soils, and rocks, with contaminants and mankind's monuments added, and deliver them to points south of the present basin. The same ice would carry vast volumes of new boulders, sands, silts, and clays (even bits and pieces of Toronto and Buffalo, freshly ground) ready, upon melting, to supply, fertilize, and regenerate the land.

Like glaciers, the lakes return their water to their source, only at a faster pace, through evaporation, transpiration, and runoff, even from below the ground. The oceans claim it all back, gathered once again to be redistributed in the atmosphere and to refresh the continents. Lakes are temporary bodies. They become overloaded with organic matter, they fill in, they empty. In basins the size of the Great Lakes, this takes place during millennia, but their inevitable breakdown can easily be accelerated through abuse and increased human activity.

Homo sapiens, able to live anywhere, and presently undergoing explosive population growth, puts immense disruptive pressures on natural ecosystems. Biological diversity is being reduced in the lake basins and elsewhere as a result of human activities such as contamination, expanded ground cover by buildings and pavements, cultivation, organic decline of farmland, and soil erosion. A preoccupation with notions of economic growth and salvation through industrial and agricultural expansion is a major contributor to the problem. Pressures for water-sharing, despite the protests of Great Lakes states political leaders, will continue because of water depletion and extensive soil loss in Western farm belts at a time when there is an expanded need for increased food production. It is even possible that within a century the "greenhouse effect" will accelerate the present postglacial rise in sea level, causing melting ice and flooding of coastal areas. Inland migrations will occur. Perhaps East Coast dwellers, realizing that life exists west of the Alleghenies, may seek new homesites in the Great Lakes basin, or make use of water and sand-gravel materials (man's two most utilized resources) for building.

The next ice age will begin with long uninterrupted snowfalls, accumulating into compressed masses of ice. The resulting glacier might be the only cleansing tool able to sweep away an overwhelming contamination that man cannot, a mechanism for large-scale regeneration, preparatory to another onslaught by man. ■

¹Some direct evidence suggests the antiquity of an elevated ridge at Euclid Ave. Several logs, unearthed in the deep excavations for the Science I and Science and Research buildings at Cleveland State University, yielded radiocarbon dates ranging from 10,600 plus or minus 100 years B.P. (Before Present) to 13,200 plus or minus 100 years B.P. Although dates (total of four logs) reflect the antiquity of the beach area, only the oldest is within limits of the expected ages of northern Ohio beach ridges. The logs may have been contaminated by younger Carbon 14 sources, perhaps deep-seated rootlets of the magnificent trees that once lined the estates of Euclid Ave.

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The Great Lakes



Redeveloping the Cleveland Lakefront

Timothy J. Runyan

The year 1986, the fiftieth anniversary of the 1936 Great Lakes Exposition in Cleveland, generated both a nostalgic longing for a revival of the spirit of that event and a hope for its repetition. A modest festival was mounted at the lakefront, including the icebreaker MACKINAW tied up at Dock 32 near some tents and marquees offering food, drink, and mementos.

With abundant parking and ready access from the downtown area, the lakefront was the natural site for the Great Lakes Exposition of 1936. The original aim of the celebrated Burnham plan for Cleveland was to extend the Mall to provide a permanent route to the lakefront. The grand Gateway Project never materialized, but hopes for a revitalized lakefront have never died. On a fine summer day on July 10, 1986, the Governor of Ohio came to Cleveland and, before the assembled company of the Mayor, the President of City Council, and congressional and state representatives, mounted an earth mover and guided its claw across the ground in the designated area between the Stadium and East Ninth Street. Earth was broken and the first step toward the Inner Harbor Project had been taken.

The cause of the current optimism is the cooperation between the city of Cleveland, the State of Ohio, and the local citizens. The North Coast Development Corporation has been empowered by the mayor and City Council to direct this effort. The 7.6-acre inner harbor along the lakefront beside Municipal Stadium is now being dug. Its purpose is the creation of a small boat marina and a pleasant downtown park. But beyond this is the hope that a maritime museum, a retail market, and an aquarium will follow. The need for an aquarium has been apparent since the old Cleveland Aquarium was closed after its roof collapsed.

The maritime museum or center, the targeted popular attraction for the Inner Harbor, will be developed by the Great Lakes Historical Society, which already possesses a foothold on the lakefront through its ownership of the W.W. II fleet class submarine, U.S.S. COD. This vessel, which draws over thirty thousand visitors each year during a brief summer season, saw action in the Pacific, winning a number of battle citations. She was reactivated during the Korean War and served on the



*Timothy J. Runyan fell in love with the sea and its vessels while studying medieval administrative history in London. Since then he has become deeply involved with maritime matters. He is president of the North American Society of Oceanic History and a trustee of the Great Lakes Historical Society. A native of Indiana, he earned a B.A. from Capital University in Columbus, Ohio, and an M.A. and Ph.D. from the University of Maryland. A professor of history at Cleveland State University, Runyan is co-author of *European Naval and Maritime History, 300-1500 (1985)* and editor of the forthcoming *Ships, Seafaring, and Society: Essays in Maritime History*.*

lakes after 1959 as a training vessel for submarine reservists. The COD was saved from the scrap yard when it was acquired by the Great Lakes Historical Society (in cooperation with a "Save the COD Committee"); in 1986 it was declared a National Historic Landmark. The Society does not expect to duplicate in Cleveland what is already in its museum in Vermilion, thirty-five miles to the west, but intends to create a new facility with hands-on exhibits as well as displays and vessels. It will be a teaching museum for school children and others, intended to educate the public about the Great Lakes, including environmental and ecological matters, and to demonstrate and preserve the lakes' maritime heritage. The COD will be joined by other boats or ships which the public can board. Immensely popular museums at Mystic Seaport, San Francisco, Salem, Newport News, and elsewhere clearly indicate the drawing power of this sort of educational entertainment.

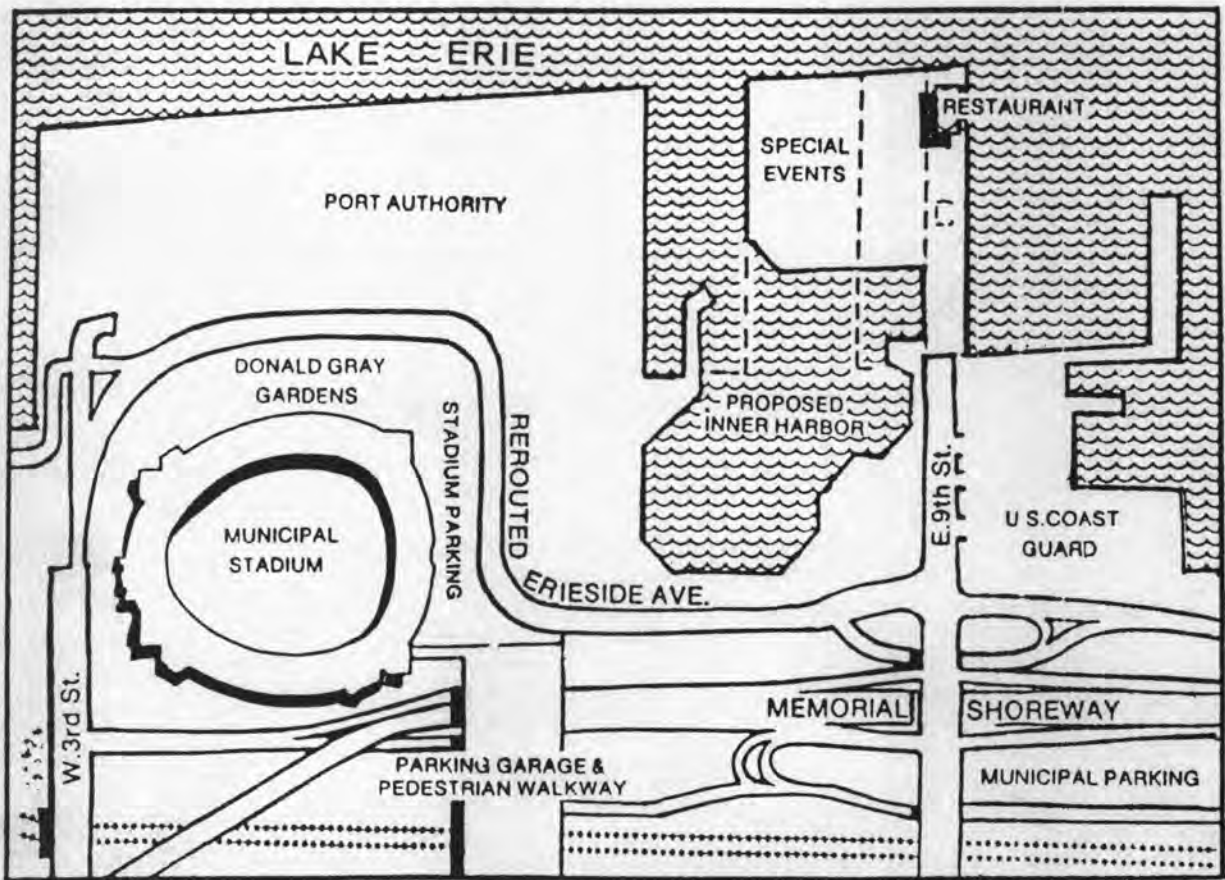
Baltimore's successful harbor development serves as an instructive model. But the Cleveland Inner Harbor would be only about one-half the size of the one in Baltimore. To achieve a larger space in Cleveland it would be necessary to expand eastward and dispossess the U.S. Coast Guard and the Army Corps of Engineers in the other harbor. A number of small craft, icebreakers, a dredge, and other vessels use this harbor and it appears unlikely that they would willingly surrender this space in the near future, considering that the site is the headquarters of the Coast Guard's Ninth District, which oversees the whole of the Great Lakes. The Coast Guard is responsible for considerable marine activity. In winter, icebreakers, such as the MACKINAW, dock there between runs. Also docked near the Coast Guard headquarters are the U.S.S. COD and vessels belonging to the Army Corps of Engineers.

The digging of the inner harbor is supposed to be completed this year, and the entire project will be finished in June, 1988. The wide promenade, which eventually is intended to draw crowds of city-dwellers and tourists, will at first offer as entertainment only a view of the transient small boats permitted to anchor in the harbor. A site for the maritime center has not yet been chosen, and the aquarium is still buried in the recesses of the plan. The harbor will have a depth of only eight feet at low water level, and cannot accommodate large vessels, certainly no bulk carriers, so representative of Great Lakes shipping. In fact, all larger vessels moored along the lakefront must beware of height restrictions imposed by the Federal Aviation Administration because of proximity to the runway paths of Burke Lakefront Airport.

What is possible for the lakefront at present is confined to the west side of Ninth Street where the power shovels are busily at work. Although less ambitious than the designers' original hope, the Inner Harbor Project is on its way. After all, Baltimore's harbor development, with its National Aquarium, the U.S.S. CONSTELLATION, and a spectacular retail market, took over twenty years to complete. As long as Municipal Stadium remains where it is and the atmosphere of a working port exists, residents of the city will continue to be drawn to the lakefront. In addition to the Corps of Engineers and Coast

Guard, the Cleveland-Cuyahoga County Port Authority operates the docks along the lakefront. When the seven-hundred-foot bulk carriers or other vessels, including "salties" from the Atlantic which have traveled the St. Lawrence Seaway, are in port, the atmosphere is distinctly nautical.

In addition to the U.S.S. COD and a teaching museum, the Society hopes to include other vessels for display, ranging from huge ore carriers to smaller craft such as tugs or fireboats. Plans include a library, lecture rooms, and an auditorium. Some have proposed an omni-max theater, a facility where an audience can experience the simulated sensation of being in flight or under water. Since most new information about maritime history comes from shipwrecks and underwater finds, a significant portion of the center will be devoted to these interests. Two intact ships from the War of 1812, the HAMILTON and the SCOURGE have been found three hundred feet down in Lake Ontario recently in near perfect condition, and there are doubtless others to be discovered.

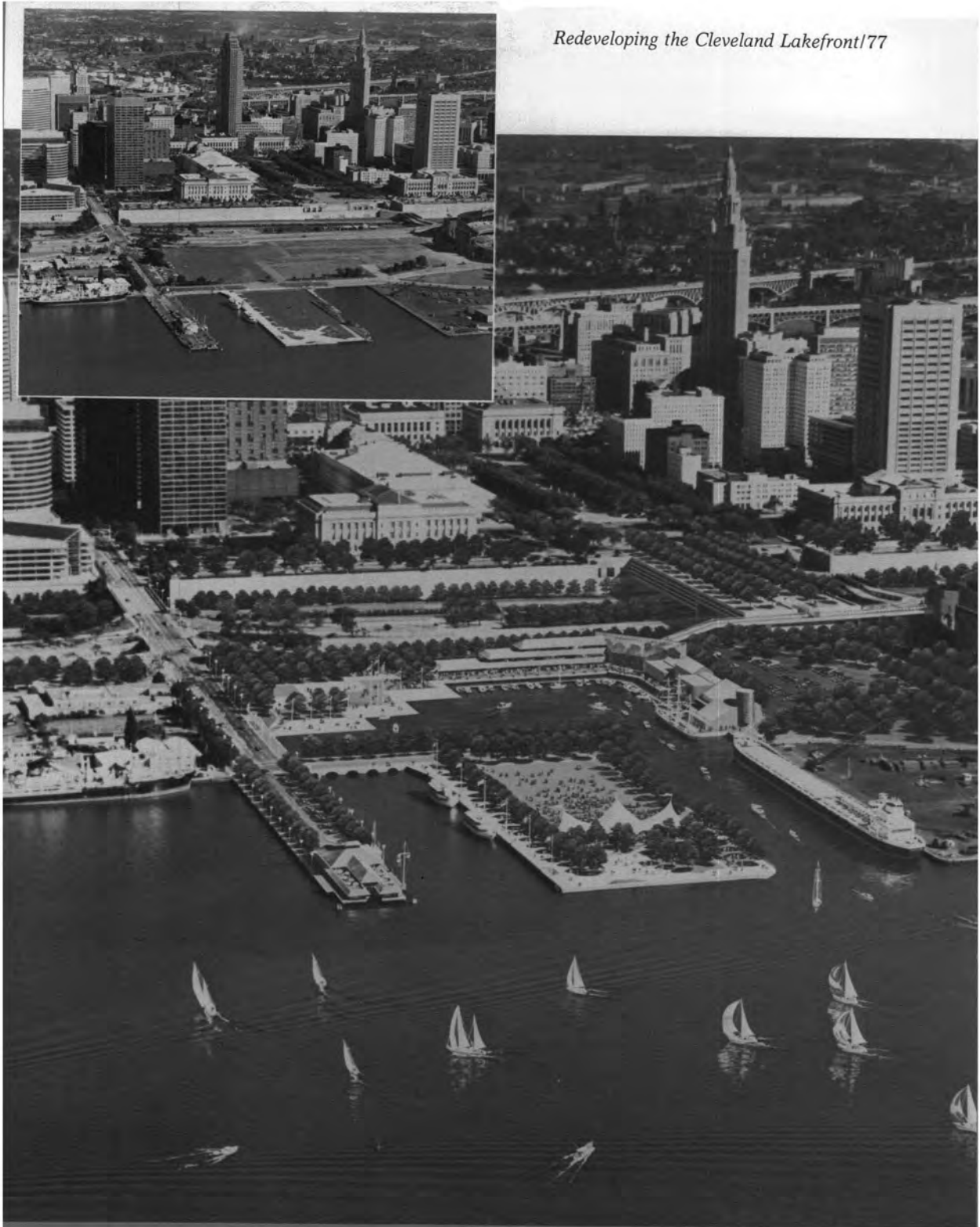


Map showing elements of proposed inner harbor project.

Right: Current view of Cleveland lakefront area that is designated for redevelopment

Poster depicting Cleveland lakefront after its planned redevelopment. Included in the mockup are a 7.4-acre inner harbor lake, a maritime museum, a wintergarden, an aquarium, a festival retail market, and festival and special events parks. The poster was donated to the citizens of Cleveland by public relations firm Edward Howard & Co

Redeveloping the Cleveland Lakefront/77



This vision is presented to the people of Cleveland by Edward Howard & Co., public relations counsel.

CLEVELAND: MAKE IT HAPPEN

Recently, a new opportunity for a ship display appeared in the form of an offer to the Society of the WILLIAM G. MATHER by the Cleveland-Cliffs Steamship Company. Longer than two football fields and standing high in the water when not loaded with the fifteen thousand tons of taconite (a silica-iron ore blend) she can carry, the MATHER represents the most typical vessel of the Great Lakes. The large bulk carriers are a product of the Lakes, both in conception and construction—in fact, the largest of them are confined to the lakes because they exceed the 735-foot limit imposed by the locks of the St. Lawrence Seaway.

Designed to carry taconite, grain, or coal, the bulk carrier is a specialized vessel which is the end product of over a century of Great Lakes shipping. Wooden schooners dominated the early carrying trade on the lakes. When sail gave way to steam, a new steel boat was designed in the 1880s (called the "whaleback" because of its rounded topsides), leading the evolution of the bulk carrier to its present form. With the collapse of domestic steel production and the use of foreign vessels to carry grain, coal, and even fresh water, out of the lakes, fewer carriers are operating and many have been scrapped. Three of these carriers, symbols of the Great Lakes, have already been transformed into floating museums: the



Sailing ships in Cleveland's harbor, circa 1878.



The WILLIAM G. MATHER, now about to be converted into a floating museum, when it was in service.

METEOR in Superior, the WILLIAM A. IRVIN in Duluth, and the VALLEY CAMP at Sault Ste. Marie. The WILLIS B. BOYER is being readied for display in Toledo and the NIAGARA in Erie. The WILLIAM G. MATHER is under consideration for restoration and display by the Great Lakes Historical Society in Cleveland. Although the expense of restoration and maintenance is high, the opportunity to acquire one of these behemoths is fleeting.

Today's waterfront enthusiast can only be encouraged by the changes occurring on Cleveland's lakefront. The Ohio Department of Natural Resources has transformed much of the waterfront into attractive marinas, fishing piers, and promenades with nearby park facilities. The conclusion of the digging and decorating of the inner harbor will add dramatically to this development. The inner harbor will be attractive to boaters as a place to tie up overnight or for short-term visits. At present, dock space for transient vessels is severely limited, so the harbor should encourage more summer visitors to come to the downtown Cleveland area. A trolley line to move people between the river and the inner harbor is part of the overall planning design and would link the two waterfronts. But more important is the realization that enjoyment is to be found in, on, and alongside the element that gives this environment its character: water. ■



Alan MacDougall

Antarctica

New Law For a New Land

Oliver C. Schroeder, Jr.

The latter years of the twentieth century have witnessed a shaking of the foundations of international law in a modest revolution that may point the way to the world's best hope for peace. The nation-state system dominant around the globe for the past five centuries has been based on the concept of sovereignty, the absolute legal authority of a government over its national territory. Such national sovereignty is illustrated in the United Nations General Assembly, where each of the 160 member states is legally equal and independent, regardless of population, territorial size, or wealth. The one large territory on earth not yet dominated by separate sovereign states is Antarctica, where, instead of the venerable system of sovereignty, a number of nations are cooperating under a legal system conceived as a commonwealth of science.

Back in 1885 at the Congress of Berlin the European nations resolved to divide among themselves the territory of Africa that had not yet come under European influence. By international consensus, new national territories in Africa would be acquired not by wars between colonizing powers, but by discovery, exploration, occupation, and settlement. When the process was completed by a European state, its sovereignty over a new territory would be established. Thus Belgium, France, Germany, Great Britain, Italy, Portugal, and Spain became colonial powers in Africa, and the Dark Continent was subjected to the legal rule of national sovereignty. Although this entire colonial system had disappeared by 1986, national sovereignty remained the legal system in Africa, as European nations transferred their rule to the new independent states.

Antarctica was the last continent available for nation-state territorial acquisitions by discovery, exploration, occupation, and settlement. But Antarctica has not gone the way of Africa. On this polar continent, representing one-fifteenth of the Earth's land surface, a hostile environment has barred effective occupation, let alone colonization. The system which has evolved over the past quarter century is a commonwealth for science with a legal system to encourage universal scientific research, not territorial colonization by one or more nation-states. How this profound change in international law occurred invites first a look at the history of man's relationship to Antarctica.



For the past twenty years, Oliver Schroeder, Jr. has taught a seminar on sea and space law, a portion of which is devoted to Antarctica. Professor Emeritus of criminal law and justice at Case Western Reserve University, Schroeder is a former mayor of Cleveland Heights, Ohio and a former member of its city council. He received his A.B. from Case Western Reserve University and his J.D. from Harvard University. In 1986 he received the James Nobel Award for Outstanding Service in Human Relations, and this year was named Gradwohl Laureate, the highest honor awarded by the American Academy of Forensic Sciences. Schroeder's publications include International Crime and the U.S. Constitution (1950) and Homicide in an Urban Community (1960).

*The
VINCENTES,
flagship of
the U.S.
Navy's 1838
Antarctic
expedition,
from which
Charles
Wilkes was
the first to
sight the
coastline of
Antarctica.*



*The X marks the
approximate location
of the meeting
between the American
Palmer and the
Russian Bellinghousen
in 1820.*

Human History in Antarctica¹

The discovery of the seventh continent is obscure. Capt. James Cook (1728-1789), who conducted expeditions in the eighteenth century to Australia and New Zealand, apparently predicted its existence when icebergs he observed suggested a possible land area further south.

In 1820 Nathaniel Palmer, only twenty-one years old, took his little sloop with one first mate and four crew members from Stovington, Connecticut, to the great southern seas seeking undiscovered seal beaches, and at the same time Fabian Von Bellinghousen, a veteran captain in the navy of the Russian Czar, was dispatched to the south seas on a voyage of discovery. When Palmer and Bellinghousen met in the area of the South Shetland Islands, Palmer explained to the Russian captain his discovery of land to the south, where he had charted a long continental shore. After this meeting, Bellinghousen went on to circumnavigate Antarctica.

The British explorer Edward Bransfield also allegedly charted "Trinity Land south of the South Shetland Islands in January 1820," but his logbook has never been found. In 1823, British Captain James Weddell sailed to 74° 15' south in the area now called the Weddell Sea. In the 1820s American, British, and Norwegian sealing expeditions pressed southward from South America to the islands off the shores of the elusive continent.

Palmer's early arrival was recognized by the geographic name "Palmer Peninsula," the long arm of land stretching from Antarctica toward South America. Today by international agreement the area is known as "Palmer Land" on the "Antarctic Peninsula." Bellinghousen's early explorations have also been acknowledged in the geographic name "Bellinghousen Sea" located west of Palmer Land. The United Kingdom in the early twentieth century based its claim of sovereignty on Bransfield's uncorroborated visit in 1820.

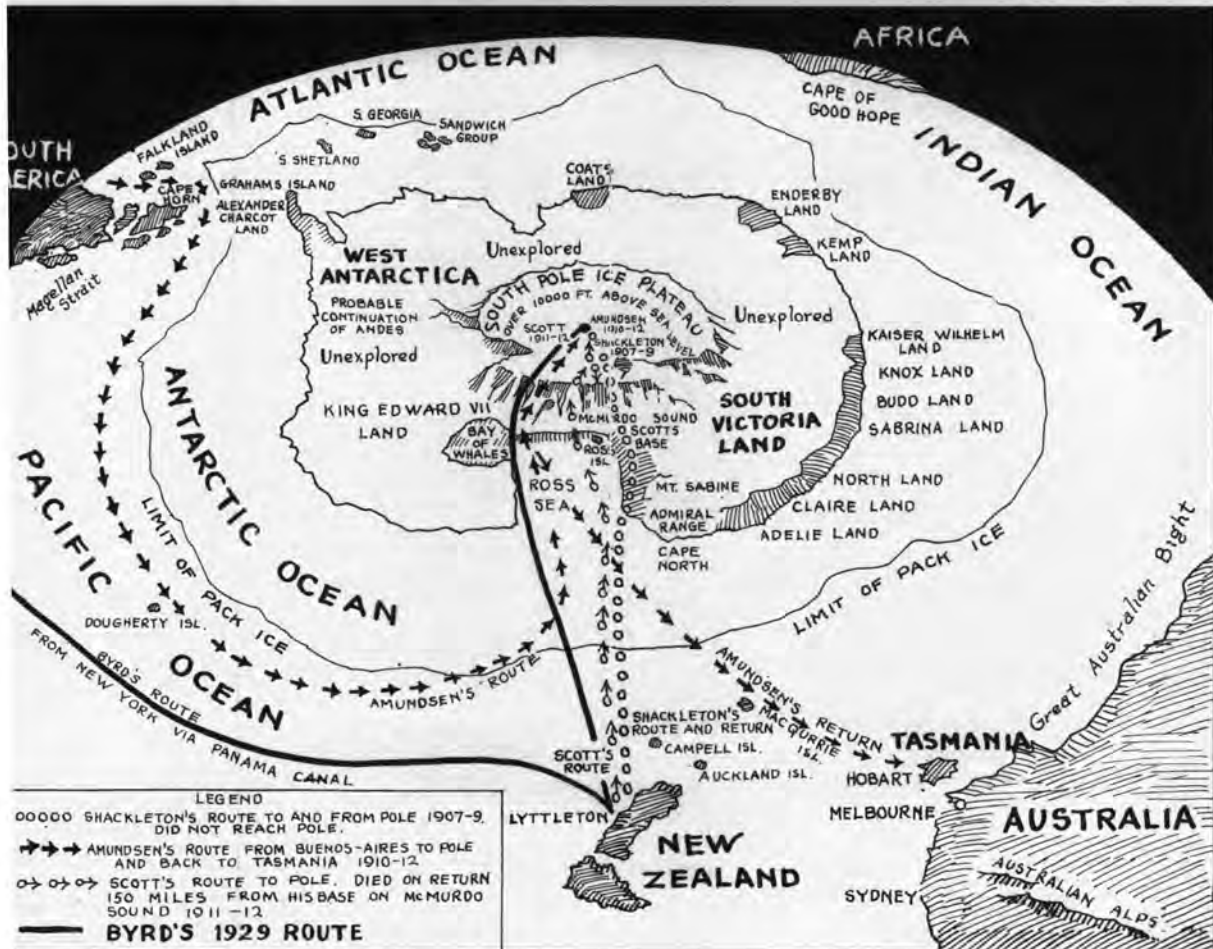
Exploration of Antarctica was sporadic during the remaining decades of the nineteenth century. The first U.S. expedition (1838-1842) under Lt. Charles Wilkes, U.S.N., reported land at 158° east on January 16, 1840. Wilkes skirted the coast westward for 1500 miles, thereby confirming the existence of the Antarctic continent. Wilkes wrote in 1845 his *Narrative of U.S. Exploring Expedition* authenticating the scientific work of this expedition. Literary scholars suggest that Herman Melville used this *Narrative* as a basis for *Moby Dick*. They see Wilkes

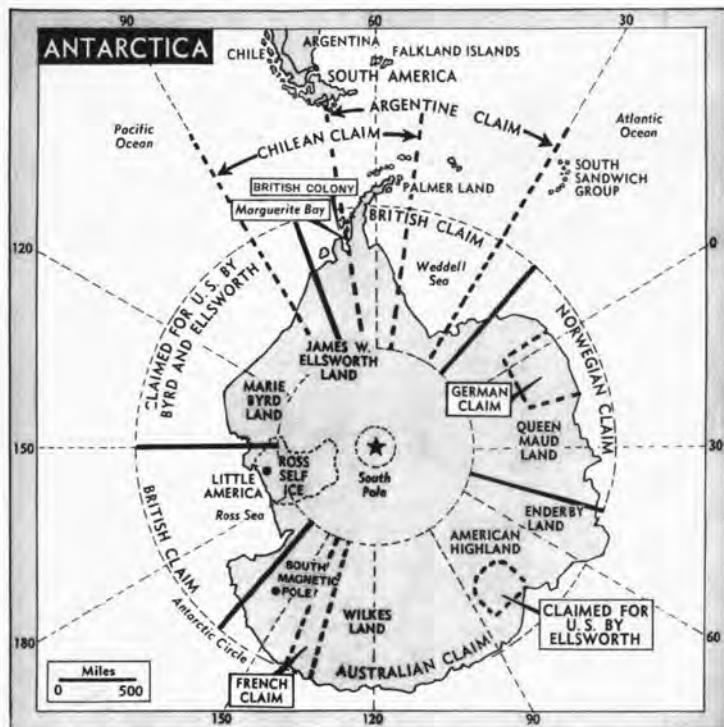
as Captain Ahab, a Maori on the Wilkes voyage as Ahab's harpoonist Queequeg, and Wilkes's obsession, the great white continent Antarctica, as the great white whale.

In 1841, Sir James Clark Ross of Great Britain discovered what is Victoria Land and bequeathed his name to the Ross Sea and Ross Ice Shelf. Matthew Fontaine Maury, who compiled world weather and oceanic data for the U.S. Navy prior to the Civil War, sought unsuccessfully to obtain aid from European governments for an expedition to the southern seas, whose impact on the world's weather and oceans he had recognized. He did succeed, however, in aiding the establishment in 1882-3 of the first international polar year in the Arctic. In March, 1898, a Belgian explorer in the Bellinghausen Sea become the first person to winter in Antarctica when his ship become frozen in the winter ice.²

With the coming of the twentieth century, mankind was challenged to locate both the South Pole and the North Pole. In what has often been termed the "heroic age" of polar explorations, the names of Robert F. Scott (1868-1912), a British naval officer, Ernest Shackleton (1874-1922), a British explorer, and Roald Amundsen (1872-1928), a Norwegian explorer, were prominent. Amundsen discovered the South Pole in 1911; Scott arrived several weeks later, then lost his life on the return journey.

Map showing explorers' routes to the pole.





Above:
The then Lt. Commander
Richard E. Byrd in 1925,
on his way to Antarctica.

Left:
Map showing the 1947
territorial claims of eight
nations.

Russia and America were conspicuously absent from this period of Antarctic exploration. Russia did not renew its activities there until after World War II. But in 1929, a year after the British explorer Sir Hubert Wilkins had landed an airplane on the Antarctic Peninsula, Admiral Richard E. Byrd, U.S.N., became the first person to fly over the South Pole. America now began vigorous exploration activities on the seventh continent. Byrd continued his efforts by becoming the first American to remain in Antarctica during the winter season. His base at Little America, which had radio contact with the outer world, could legally be the basis for an American claim to occupation of a portion of Antarctica. With such occupation recognized, the basis for establishing American sovereignty over some portion of the continent would exist. But the United States has never made any explicit claims to sovereignty in any Antarctic territory. It has preferred to link the importance of the continent to an insistence that it remain undivided, while seeking a basis for future territorial claims if the need arises.

The extent of American influence over Antarctic exploration is manifested in the number of U.S. geographical names appearing on maps and charts. Palmer Land, Marie Byrd Land, Ellsworth Mountains, Wilkes Land, and the American Highland are a few. In 1947-8, America introduced the first women to winter on the continent. The wife of Capt. Finn Ronne, USNR, and a companion were part of Ronne's expedition based on Stonington Island.

The birth of the idea that Antarctica should be a commonwealth for science rather than a collection of sovereign territories of individual nation-states probably occurred in 1950 at a dinner party given by James Van Allen, the American astronomer, for some fellow scientists at his Silver Springs, Maryland, home. At this gathering the idea emerged to dedicate the



Third Polar Year of 1957 to Antarctica. Scientists around the world became enthusiastic over the idea. The result was the International Geophysical Year (I.G.Y.), eighteen months in 1957-1958 when scientists of all nations would cooperate to experiment with matters involving not only Antarctica but the Earth's oceans and the space above the Earth. This was an ideal time because it coincided with maximum sunspot activity, thus permitting the best study of solar influence on the earth's ionosphere.

The I.G.Y. was a triumphant idea. It permitted the U.S. to play a role in Antarctica and provided it with an opportunity for cooperation with the U.S.S.R. during the cold war. The last continent was to be subjected to scientific research as the basis for the creation of a new legal commonwealth. The concept of national sovereignty, by which the Congress of Berlin divided up Africa in 1885, was not replicated on the seventh continent in 1957-8.

Admiral Byrd with the U.S. Navy's "Operation Deep Freeze," 1955-6, provided the most extensive activity ever attempted in Antarctica. Five coastal stations facing the Indian Ocean were established; over one million square miles were explored in Wilkes Land. Then on October 31, 1956, Admiral George Sufek, commanding U.S. "Operation Deep Freeze II," landed by airplane at the South Pole. A camp was established. Dr. Paul Siple and seventeen others remained for the Antarctic winter to conduct scientific research. When they established this polar camp, a 45-year-old photograph of Robert Scott's ill-fated party in 1912 aided them in fixing the hardness of snow for bearing the load of the aircraft skis. The U.S. has maintained this South Pole station continuously since 1957. By 1958 Sir Vivian Fuchs and his British Trans-Antarctica Expedition had crossed the continent's 2158 miles via the South Pole.

U.S. Navy icebreakers team up to move an iceberg out of McMurdo station's shipping channel.

Meanwhile, the law for Antarctica had its birth in 1948 with the Escudero Declaration proposed by Chile. It offered a five-year moratorium on territorial claims to sovereignty, a concentration on scientific research with free access to the land, and political neutrality for the scientists. In 1956 President Eisenhower adopted as U.S. Antarctica Policy emphasis on "down on the ice science" rather than mapping the continent to make territorial claims. The door was thus opened on the last continent not only for new science, but for new law.

The scientific work of the I.G.Y. was viewed originally as a temporary eighteen-months' experience. The success of the scientific activities in Antarctica indicated, however, great need for some kind of permanent legal arrangement. For nearly two years, diplomats of the 12 nations involved in Antarctic scientific studies met in the National Academy of Science board room in Washington D.C. to draft a basic legal document. In 1959 the Antarctica Treaty was signed. President Eisenhower in his State of the Union Address in 1960 hailed the treaty with these words: "There is one instance where our initiative for peace has been successful. A unilateral treaty signed last month provides for the exclusive peaceful use of Antarctica, assured by a system of inspection. It provides for free and cooperative scientific research in that continent, and prohibits nuclear explosion The treaty is a significant contribution toward peace, international cooperation, and the advancement of science."

By 1961 ratification and acceptance by Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the United Kingdom, the U.S., and the U.S.S.R. brought the treaty into force.³

A legal charter for a commonwealth of science had, for the first time in history, replaced the traditional legal concept of nation-state territorial sovereignty for a land area. Also in February, 1961, the U.S. Navy icebreakers *Glacier* and *Staten Island* penetrated farther into the Bellinghousen Sea than any previous ship. Now the practicality of major exploration and occupation to effect a working regime for Antarctica under the treaty was established.

The Antarctica Treaty

The treaty applies not only to the land mass of the continent but to the entire area, both land and sea, south of 60° south latitude (Article VI). The right of every nation-state to use the high seas in the area is preserved, but only peaceful pursuits are allowed. All activities of a military nature are prohibited (Article I), and nuclear explosions and the disposal of radioactive wastes are forbidden (Article V). The treaty guarantees freedom of scientific investigation (Article II) and obligates participating nations to cooperate and to share information about scientific programs, the use of scientific personnel, and scientific observations and results (Article III).

The treaty specifically addresses the historic issue of territorial sovereignty. Claims of territorial rights made before 1959

by Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom are suspended. Nothing in the treaty is to be interpreted as a renunciation of such "previously asserted rights or claims to territorial sovereignty in Antarctica"; but, more important, no acts taken under the treaty shall "constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica" (Article IV). Participating nations may place their stations anywhere. For the past thirty years territorial sovereignty in Antarctica has been a moot issue and will doubtless remain so until the treaty's expiration in 1991.⁴

A major provision that prevents establishment of territorial sovereignty is the right of observers from any nation to inspect the activities and facilities of any and all other nations. Each duly authorized observer has "complete freedom of access at any time to any or all areas of Antarctica . . . all areas shall be open at all times to inspection by any observers designated in accordance" with the treaty (Article III). There are no customs or immigration officials in Antarctica. Aerial observation is permissible over the entire treaty area. Advance notice must be given by a member state to all other treaty nations, informing them of all expeditions, all stations, and any military personnel or equipment being used for scientific activity.

What is the legal status of an individual in Antarctica? Without territorial sovereignty, to which nation does a person owe allegiance? For acts or omissions occurring in Antarctica, all persons are subject to the legal jurisdiction of the member state of which they are nationals (Article VIII). The legal status of U.S. nationals who are tourists in or over Antarctica follows a similar rule. In one instance, U.S. nationals were killed in Antarctica while sightseeing from a New Zealand airplane. Representatives of the deceased persons' estates sued the U.S. government alleging negligence of U.S. weather and navigation officials. They based the U.S. government's liability on the Federal Tort Claims Act, which, however, is not operable in a "foreign country." The U.S. Court of Appeals, interpreting the Tort Claims Act and the treaty, held that Antarctica was in this case not considered a foreign country, so the decedents' representatives had jurisdiction to sue the U.S. government.⁵



Scientists in a motorized rubber raft move closer to the cliff-like edge of an iceberg.

Articles IX and XI provide procedural machinery. The governing body, called the Consultative Group, is composed of one representative from each nation, and is responsible for information exchange and formulation and recommendation of necessary measures to effect the treaty's purposes. When disputes arise between nation members, Article XI requires resolution by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement, or other peaceful means. Any dispute not so resolved is to be referred to the International Court of Justice.

A nation that is not an original member may accede to the treaty, and in doing so it obligates itself to abide by the substantive rules of conduct. But such a nation does not automatically become a member of the governing Consultative Group. To do this it must "demonstrate its interest in Antarctica by conducting substantial scientific research activity there, such as the establishment of a scientific station or the dispatch of a scientific expedition" (Article IX).

Fifteen nations have acceded to the treaty without becoming members of the Consultative Group. Brazil, India, Poland and West Germany, however, have demonstrated sufficient



One of many field camps that are offshoots of the base stations maintained by the nations participating in Antarctic exploration and research.

scientific interest to join the original twelve members. The People's Republic of China is also in the process of becoming a full member, which would bring the total number of fully cooperating nations to seventeen.

With China's membership all of the five permanent members of the U.N. Security Council will be involved. Because Brazil and India are considered developing nations, their presence has muted earlier criticism that the Antarctica Treaty organization was a closed shop of developed nations.⁶

Open Inspection: An End to Sovereignty

The right of one member nation to observe and inspect any other member nation's station or operation, spelled out in Article VII, completely eliminates the national sovereignty principle. Even under historic international law for the free and open high seas, no nation may board the vessel of another nation except under severely limited conditions. Yet Antarctica and all of its facilities regardless of national origin are open and free for observation and inspection.

Between November 8th and 25th, 1985, the United States sent an observer team to inspect the stations of six countries. Five of them were on King George Island near the historic 1820 meeting place of Bellinghausen and Palmer: Marsh/Frei (Chile), Bellinghausen (U.S.S.R.), Jubany (Argentina), Great Wall (China), and Arctowski (Poland). The sixth station, the British Faraday, was on the Antarctic Peninsula. The American inspection team consisted of three representatives of the U.S. Department of State, one National Science Foundation representative, and a naval officer on detail to the U.S. Arms Control and Disarmament Agency. Selection of team members was made by the Under-Secretary of State for Security Assistance, Science, and Technology. The 1985 observer team represented the eighth in a series of U.S. inspections since 1961.

In its official report⁷ the U.S. inspection team stated that "no arms control, environmental or other violations of the Antarctica Treaty" were found. A spirit of close cooperation was noted in all stations visited, and mutual support in crisis situations was normal procedure. "Both scientific and support personnel displayed enthusiastic commitment to the preservation of Antarctica as a natural laboratory for scientific research," the report concluded.

The U.S. observer team did identify several minor problems. Limited hydrocarbon seepage was observed at each station. Protection of the local environment against the possibility of massive oil leakage was needed. Trash disposal included the burning of plastics and dumping plastic garbage bags into the sea, even though these procedures violated the Antarctica Code of Conduct Handbook. Removal of bulk waste materials such as steel cabinets and machinery remained a challenge. Efficient trash compaction was suggested. Sewage disposal was a constant problem; only the Polish Arctowski station handled it properly, using a five-stage sewage filtering system and monitoring the effluent as it enters Admiral Bay.

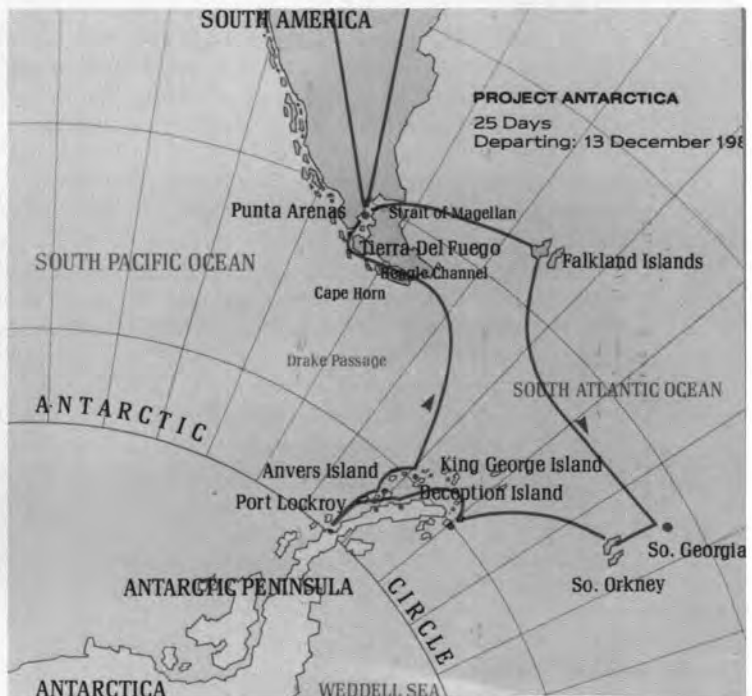
One unique growing problem in the area inspected was tourism. More than one thousand tourists were to visit the Polish station in 1985-1986. The Chilean station was to receive several hundred. The saturation point for tourist visitations has been reached on King George Island. In addition, a growing number of "adventure" tourists traveling into remote areas taxes Antarctica's search and rescue capabilities. It is suggested that the nations sponsoring such tourism should be responsible for the safety of the tourists. Some refuge supplies cached by scientific stations for emergency use in the field have been taken by private tourists without reporting the removal. The scientific stations on King George Island are considering the establishment of an "easily noticed, standardized marking system to delineate sites of Special Scientific Interest and Specially Protected Areas" which tourists would be asked to avoid.

Clockwise from top left: Helicopters give tourists access to the more remote areas of Antarctica.

Visitors arriving at McMurdo Station.

Map showing a typical tourist route to Antarctica, beginning in the Falklands and hitting several spots on the Antarctica Peninsula.

A tourist group approach a landing on the Antarctic ice shelf.



In view of the world confrontation between the U.S. and U.S.S.R. on arms control and the rights of inspection and verification, it is interesting to study the U.S. team's report on its visit to the Soviet Bellinghausen Station. Located just five minutes' walk from the Chilean Marsh/Frei station across the six-inch-wide "Volga" river, the U.S. team was cordially received on arrival. Seventeen years of Antarctica weathering of the Soviet station suggested need for repair. Complete renovation is scheduled for 1987. Among the personnel stationed at Bellinghausen were nineteen scientific and technical persons (two from East Germany), two doctors, four mechanics, and one cook.⁸ The station is located on two levels. The upper level of a steep slope houses the radio and geodesic satellite monitoring equipment with personnel. Below lie the major buildings spread over level land.

Scientific activities at Bellinghausen include ionospheric research, biological research, a geodetic satellite tracking system, and meteorological monitoring. Seven Soviet vessels deliver supplies during the summer. Unlike others stationed on King George Island, the Soviets do not use the airstrip at Chile's Marsh/Frei station. Water comes from the lake which also supplies the Chilean station. It is not treated after use and untreated sewage is dumped into the bay. Combustible waste is incinerated. Scrap metal is returned to the U.S.S.R. No arms are kept at the Russian station. Incidentally, only at the United Kingdom and Chilean stations were any arms (pistols and rifles) observed by the American inspection team.

No other land territory on earth is open to such observation and inspection. Science has united Antarctica into one commonwealth with one legal system.

The Growth of Law in Antarctica⁹

The commonwealth law has grown modestly through a quasi-legislative process. The most inclusive legislation drafted by the Consultative Group, the Convention on Conservation of Antarctica Marine Living Resources, took effect in 1982.¹⁰ While attached to the Antarctica Treaty through a legal "umbilical cord," the Convention, with headquarters in Hobart, Tasmania, has been ratified by states other than those involved in the Antarctica Treaty Commonwealth, including the European Economic Community.

The Antarctic commonwealth nations along with their scientific committee base their management of marine resources on an understanding of the unique ecosystem in the oceans encircling the Antarctic continent. The Convention on Conservation followed the earlier Convention for the Conservation of Antarctic Seals adopted ten years earlier in 1972.¹¹ For the purposes of the Convention, "conservation" is defined to include "rational use." The harvesting of marine living resources must be compatible with these aims:

1. To prevent a "decrease in the size of any harvested population to levels below those which ensure its stable recruitment."



2. To maintain the ecological relationships between the "harvested, dependent and related populations" of marine living resources.

3. To prevent changes or to minimize the risk of changes in the marine ecosystem "not potentially reversible over two or three decades."

The Conservation Convention nations acknowledge the special responsibility of the Antarctica Treaty nations to preserve the environment in the Treaty area south of 60° south latitude. Actually the Conservation Convention covers a broader geographical area, since it applies to the marine living resources which are found south of the Antarctic convergence, the line in the sea where the cold waters of the Antarctic oceans meet the warmer waters of the Atlantic, Pacific, and Indian Oceans. This boundary drawn by nature delineates the true extent of the Antarctic marine living resource ecosystem.

A second organ of the fledgling government for the marine living resources is the Scientific Committee, which cooperates in the collection, study, and exchange of information, and promotes cooperation in scientific research on marine living resources. A recent example of the legislative process shared by the Commission and Scientific Committee involves the protection of Antarctica's penguins and other marine life from lethal plastic debris. No international measures forbid the dumping of plastic debris at sea. Several protective measures were adopted to prevent the discarding of plastic nets and materials which can kill birds, animals, and fish by ingestion or entanglement. The representatives also agreed to recommend ratification by the Convention nations of Annex V to the Convention which prohibits such dumping.¹²

This recent session achieved agreement on a plan to prevent ships engaged in "research fishing" (non-commercial fishing to determine the status of depleted fish stocks) from over-harvesting protected species, and also on a U.S. sponsored system to inspect commercial fishing for compliance with existing protections of over-fished species. A ban on fishing for one over-fished species was adopted while the bans on fishing for two other depleted species did not receive approval.

Left:
Penguin rookery at
McMurdo Sound.

Above:
An elephant seal,
protected by the 1972
Convention for
Conservation of Antarctic
Seals.

New law for the old problem of boarding the ships of another sovereign nation on the high seas is also established by this Conservation Convention. Traditional international law forbids such invasion of a state's "territorial sovereignty." But the Convention's Article XXIV permits boarding and inspection in line with the international cooperation that exists elsewhere among the member nations.

Today's Challenges to the Antarctica Treaty¹³

As the treaty approaches its year of decision, 1991, when its members must choose continuation, modification, or expiration, several powerful economic factors are emerging. The treaty has worked well for scientific research and the production of knowledge for human use. The degree of sharing such knowledge regardless of the nationality of the scientists has been a most important achievement. But with the potential production of material resources, the sharing of economic wealth is a new problem. Traditionally material resources are owned and used by the citizens of a single nation-state. How can the commonwealth of science share the several valuable economic resources which now exist or may exist in Antarctica?¹⁴

One such resource is krill, the shrimp-like creatures that provide a major food source for whales, seals, squids, and seabirds. Each year man harvests about 500,000 tons of krill, equal to the biomass of 10,000 whales. Economists envision krill as a major food source for the world's hungry people. But how can this take place under the treaty?¹⁵

Though mineral and petroleum production in Antarctica will not be economically feasible in the near future, geologists suggest the high possibility of a great cache of minerals hidden under the thick ice covering the continent. Historically, nations have fought to *own* such resources because ownership means wealth. Can the precedents of international sharing established by the treaty be extended to mineral rights?¹⁶

Perhaps the most valuable resource in Antarctica will not be the economic wealth of krill and minerals, but the scientific knowledge which explains the effect of ice on weather and sea level during changes in climate. If so, the unique importance of the commonwealth of science will grow. A diplomacy of science will emerge. The efforts of world scientists to improve the quality of life may well take precedence over economic exploitation fostered by nationalistic politicians.¹⁷

The new legal regime replacing national sovereignty with a scientific commonwealth is a means of civilizing international relations. There has been no cold war in Antarctica, only cold climate. In fact the Antarctica Treaty has overcome even a hot war. While Argentina and the United Kingdom were locked in military combat in the Falkland Islands, their representatives were meeting and cooperating in peace at the regular meeting of the Antarctica Treaty Consultative Group.¹⁸ The experience of freedom of movement under the Antarctica Treaty, unencumbered by territorial boundaries, provides worthy examples for nations seeking the elimination of arms through the right of inspection in Europe and North America.

In 1957, during the International Geophysical Year, Harrison Brown (Professor of Geochemistry at California Institute of Technology), James Bonner (Professor of Biology and Genetic Engineering at California Institute of Technology), and John Weir (a consulting mining engineer), wrote in *The Next Hundred Years*:

When we take the very long view of man's world in the next century we see that the main problems are less those of technology than they are of men getting along with other men, communicating with other men, and organizing themselves in such a way that their genius and imagination can be vigorously applied to the problems that confront them. Our major problems involve the enriching, enlarging, improving, and mobilizing of our intellectual forces.¹⁹

To no small degree the legal regime created for Antarctica has responded to the prophecy of these scientists.

From 1987 through 1991, when the Antarctica Treaty is reconsidered, thoughtful men and women of all nations will watch Antarctica closely. Will the prophecy held out in *The Next Hundred Years* emerge? The Commonwealth of Science could become the primary legal concept for a regime of law that goes far beyond Antarctica to the High Seas and even to Outer Space. If it does, maybe mankind will have learned the secret of peace. ■



Notes

¹For excellent discussion of the historical activities of man in Antarctica, see Deborah Shapley, *The Seventh Continent* (Baltimore: Johns Hopkins University Press, 1985), Chaps. 1-3; David M. Tyree, "New Era in the Loneliest Continent" and "Filling in Antarctica's Blank Spaces" with Supplemental Map, *National Geographic Magazine*, February 1963, 260-296, 297-298.

²Frederick A. Cook, *Through the First Arctic Night* (New York: Doubleday and McClure, 1900). Winter freeze-ups of supply ships to Antarctica still challenge man. The U.S.S.R. uses ships rather than airplanes to supply its Antarctic stations. In July 1985, a dramatic rescue of a Russian ship frozen in the ice of the Antarctic winter was effected by a Soviet ice-breaker dispatched from Vladivostok. Sean Williams, "Soviet Icebreaker Attempts Dramatic Antarctica Rescue Mission," *Christian Science Monitor*, 23 July 1985, 9; "Captain of Soviet Ice Breaker Describes Daring Rescue of Supply Ship," *Christian Science Monitor*, 22 August 1985, 28. New Ships for operation in the Antarctic winter are being tested. See Michael Parfit, "A New Ship Tests the Rigor of Winter in the Antarctic," *Smithsonian*, November 1986, 117-127.

³Antarctica Treaty, 12 U.S. Treaties 794; 40 U.N. Treaties 71 entered into force June 23, 1961.

⁴For the current status of these prior claims of sovereignty by the several Treaty participating nations see Gale Wainer, "Staking Claims on the Last Frontier," *Sierra Club Bulletin*, July/August 1984, 50-54; and Louis Wiznitzer, "Who Owns Antarctica?," *Christian Science Monitor*, 14 February 1985, 16-17.

⁵U.S. v. Beattie, 756 Fed. 2d. 91 (Washington, D.C., 1984).

⁶For the political implications of the "exclusive club" criticism of the Antarctica arrangement see Lee Kimball, "Unfreezing International Cooperation in Antarctica," *Christian Science Monitor*, 1 August 1983, 23; Louis Wiznitzer, "United Nations Turns the Heat on Antarctica's 16-Nation 'Club,'" *Christian Science Monitor*, 4 October 1983, 12; Louis Wiznitzer, "Small Nations Protest Bigger-Power Claims to Antarctica's Riches" *Christian Science Monitor*, 19 November 1984, 21-23; Lee Kimball, "Getting Together on Antarctica in the 80's," *Christian Science Monitor*, 17 December 1984, 17. Current scientific activities are discussed in Michael Parfit, "The Last Continent," *Smithsonian*, October 1984, 48-61; R. Norman Matheny, "A 'Put-In' on a Frozen Frontier," *Christian Science Monitor*, 20 February 1985, 16-17; Uwe Radok, "The Antarctic Ice" *Scientific American*, August 1985, 98-105.

⁷This report can be obtained from Office of Oceans and Polar Affairs, Department of State, Washington, D.C. 20520.

⁸Personnel at stations other than Bellinghousen included: United Kingdom: total 18—eight scientists with one doctor and nine support personnel.

Chile: total 200—air force personnel, family members, civilian technicians, support staff, and several employees of the Chilean National Tourist Bureau. Four pupils attend school taught by two teachers. Three Chilean babies have been born on King George Island, Antarctica's first natives.

People's Republic of China: Eight persons compose the winter-over party. The summer complement is 42 including three Chilean scientists and two scientists from Hong Kong.

Argentina: There are 12 on the winter team—five biologists, two geologists, one meteorologist, two mechanics, one radio operator, and the station leader. In summer the personnel doubles.

Poland: Seventeen scientists and technicians compose the winter team. The summer average is 30 persons with a maximum of 70. Also present during the U.S. inspection were scientists from the U.S., West Germany, and Brazil.

⁹The law and politics of Antarctica are intertwined. For excellent general discussions on these matters see F.M. Auburn, *The Ross Dependency* (The Hague, Netherlands: Nijhoff, 1972). F.M. Auburn, *Antarctic Law and Politics* (Bloomington, IN: Indiana University Press, 1982); Philip W. Quigly, *A Pole Apart: The Emerging Issue of Antarctica* (New York: New Press, 1983); Gerold S. Schatz, ed., *Science, Technology and Sovereignty in the Polar Regions* (Lexington, MA: Lexington Books, 1974).

¹⁰Antarctica Marine Living Resources Convention, TIAS 10240, Treaties in Force, Current State Dept. Bulletin, May 1, 1986.

¹¹Convention for the Conservation of Antarctic Seals, *Treaties and Other International Agreements on Fisheries, Oceanographic Resources and Wildlife Involving the U.S.*, Congressional Record, 95th Cong. 1st sess., 1977, 136-144. Entered into force March 11, 1978, with these states as parties: Argentina, Belgium, Chile, France, Japan, Norway, Poland, South Africa, U.S.S.R., U.K., U.S.

¹²"EDF at Antarctica Conference, Spurs action on Plastics and Other Threats," *EDF [Environmental Defense Fund] Letter*, December, 1986, 1. See General Barney Brewster, *Antarctica: Wilderness at Risk* (San Francisco: Friends of the Earth Books, 1982).

¹³Louis Wizenitzer, "Antarctica: Bottom of the World Moves to the Top of the World's Agenda," *Christian Science Monitor*, 18 January 1983, 12-13.

¹⁴Michael Parfit, "Nations are Debating the Future of the Antarctica's Frozen Assets," *Smithsonian*, November 1984, 46-59.

¹⁵See Editorial, "All For the Want of Krill," *Oceans*, January/February 1980, 2.

¹⁶John C. Bekrendt, ed., *Petroleum and Mineral Resources of Antarctica*, no. 909 (Alexandria, VA: U.S. Geological Survey, 1983); David K. Willis, "Nations Jockey for Positions to Share in Antarctica's Mineral Wealth," *Christian Science Monitor*, 28 July 1983, 1, 12.

¹⁷Harry B. Ellis, "Antarctica: A Continent Where Diplomacy Keeps the Peace," *Christian Science Monitor*, 14 November 1983, 24-25.

¹⁸For the importance of the Falkland Islands to the United Kingdom's Antarctica operations see Arther Thayer, "Britain Mulls Antarctica Link for Falklands Communications and Satellite Pictures," *Christian Science Monitor*, 21 November 1983, 26-63.

¹⁹Harrison Brown, James Bonner and John Weir, *The Next Hundred Years* (New York: Viking Press, 1957), 153-4.



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