State of the Lakes Ecosystem Conference 1996

HIGHLIGHTS OF BACKGROUND PAPERS

Prepared for the

SOLEC STEERING COMMITTEE

by

Jack Manno
Suni Edson

Great Lakes Research Consortium
SUNY College of Environmental Science & Forestry
Syracuse, New York

and

SOLEC '96 Organizers

November 1996

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Introduction

In signing the Great Lakes Water Quality Agreement, the governments of the United States and Canada committed to restoring and maintaining "the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." They also agreed to adopt an ecosystem approach to management, which means, at a minimum, a commitment to improve understanding of the complex ecological relationships that comprise the Great Lakes basin and use that understanding to minimize the negative impact of human activities on the Great Lakes ecosystem One of the purposes of the 1996 State of the Lakes Ecosystem Conference (SOLEC), whose background papers are summarized here, is to provide information about the state of the nearshore areas of the Great Lakes that can be used by all levels of decision-making and management to help fulfill these commitments.

The nearshore zone is where life is concentrated. It includes the relatively warm, shallow and productive waters near the shore, coastal wetlands, and the land areas directly affected by lake processes. It is also the portion of the Great Lakes ecosystem most crowded with humans and our activities. In the end, the commitment to maintain the chemical, physical and biological integrity of the waters of the Great Lakes basin ecosystem means learning how to apply what we know about the ecology of the Great Lakes to better manage human impacts on the nearshore environment. SOLEC's purpose is to assess the condition of nearshore ecosystems and discuss what improvements can be made.

The background papers prepared for SOLEC '96 describe the ecology of each component of the nearshore zone, the impacts of various stressors, the sources of these stressors and the condition of the coastal areas in terms of ecological integrity. Although it would be valuable if we could, it is not possible to simply go out and measure ecological integrity. We need indicators: measurable variables which provide insight and information about the state of an ecosystem.

One of the most important outcomes of SOLEC is the effort to derive indicators for measuring the state of different components of the Great Lakes basin ecosystem. The effort to derive indicators of ecological integrity is complicated by the fact that like "health", a closely related concept, "integrity" is sometimes only noticed when it fails. In ecology, as in everyday speech, the term "integrity" describes a state of healthy functioning -- a core stability that endows character, recognizability and wholeness. Some indicators, such as the "Representation of biodiversity in lakeshore parks and protected areas," which is listed in the nearshore terrestrial paper, are relatively direct measures of the protection of ecosystem health. Other indicators, such as "urban population density," described in the land-use paper, reflect the belief that societal trends toward urban sprawl and more land being used per household, results in ecological degradation. Indicators can be site specific, such as the diversity and abundance of aquatic invertebrates in a given wetland, while others have lake or basin-wide relevance, such as population size of wetland-dependent waterfowl. The advantage of developing such indicators is that once identified, they can be measured over time and trends can be assessed and interpreted.

Ecosystems are basic functional units of nature. They are identifiable as a complex set of relationships in which energy is exchanged between and among living and non-living components, and in which all parts adapt to conditions others produce and which together comprise a system capable of self-organization and recovery from stress or disruption. Over long periods of time, the species which comprise an ecosystem come to depend on each other and on the unique physical conditions to which they've adapted. Thus, highly evolved and complex communities of organisms become established. These systems evolve over centuries under conditions of gradual change interspersed with regular patterns of sudden change such as fires or rising and falling water levels. Such sudden change eliminates species that cannot survive these events. What remains are communities especially suited for particular patterns of change. The native species and living communities contain within their genetic makeup the "memory" of the thousands of years of conditions they have survived within the Great Lakes basin. The greater the number of complex communities that exist, the more varied and rich the genetic diversity, the more stable and resilient the ecosystem, and the more ecosystem integrity is maintained.

Human activities can change conditions in an ecosystem rapidly, however, and often too quickly for the system to adapt. As a result, the ability of the system to maintain integrity or wholeness becomes compromised. Unstable conditions in an ecosystem open niches for invading organisms, some transported here long distances by human activity and others simply neighbors taking advantage of newly favorable conditions for their spread. Often, the effects of these invasions further simplify the system. When this happens over and over again, special ecosystems lose their unique character and give way to new communities of organisms better adapted to human-influenced conditions. A homogenization and simplification occurs, diminishing the entire ecosystem.

A commitment to ecosystem integrity suggests, therefore, the maintenance of conditions in which rare ecosystem types are preserved. For the Great Lakes near shore, this means sufficient examples of predominant Great Lakes ecoregions must be protected so that the conditions within which the basin ecosystem evolved are maintained. Protection efforts must include viable populations and communities that are representative of the full range of nearshore ecosystems throughout the basin. A commitment to ecosystem integrity also suggests the need to apply the knowledge we have gained in studying ecological systems whenever we make decisions that will affect any part of the Great Lakes.

The state of the nearshore areas of the Great Lakes varies from near pristine in parts of the Lake Superior basin to severely impacted throughout much of the Lower Lakes. During the period from European settlement until the first Great Lakes Water Quality Agreement in 1972, forests were cleared for timber and agriculture, top predator fish were fished to extinction, stream flows were reengineered, waste products from cities and industries choked off life in the nearshore regions, shorelines were transformed and exotic species flourished. Although the era of ignoring environmental consequences has mostly passed, the legacy remains. Faced with this legacy, much has been accomplished, including a significant reduction in the worst of toxic chemical pollution of the nearshore, and widespread recognition of the importance of protecting the ecological integrity of the lakes.

There is a fundamental challenge facing managers and decision-makers of the Great Lakes basin. They must be able to understand that the nearshore region is an ecosystem unto itself. Enough information to make informed decisions must also be obtained. Specific challenges that must be met in the next two years include:

1. Bringing together available information on the state of the nearshore ecosystem into accessible GIS (Geographical Information Systems) based formats and systems.

2. Developing easily understood indicators.

3. Integrating the concepts of biodiversity and habitat into existing programs.

4. Integrating LAMPs, RAPs, and fisheries management plans so that they become fully viable management mechanisms, useful for decision makers throughout the Great Lakes basin ecosystem in taking action and assessing results.

The following articles describe in detail the current status and major trends of important components of the nearshore waters, coastal wetlands and nearshore lands. An analysis of the state of information about the Great Lakes nearshore ecosystems is included as well. These articles provide background and direction to the Canadian and U.S. commitment to restore and maintain the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem.

Nearshore Waters

Not all water in the Great Lakes is equal. Not only is each Lake unique in geological, biological and chemical characteristics, but in addition, the water of the Great Lakes is divided into two general classifications -- offshore and nearshore waters. The nearshore is a band of water found along the perimeter of each Lake that serves as critical habitat for nearly all species of Great Lakes fish and many types of birds and mammals. Specifically, the nearshore waters begin at the shoreline, or lakeside edge of coastal wetlands, and extend offshore to areas with water warm enough to support a community of warm water fish and associated organisms.

The width and amount of the nearshore waters in each lake varies, depending on the size and shape of the lake basin. In general, the nearshore consists of coastal areas less than 30 meters in depth, except in Lake Superior where they are less than 10 meters. While less than 5 % of Lake Superior is considered "nearshore", more than 90% of Lake Erie is. The Great Lakes connecting channels, Lake St. Clair, the lower reaches of the Great Lakes tributaries, and the waters around islands and offshore shoals are also considered nearshore waters.

Unlike the deeper, colder offshore waters, the nearshore is linked physically to coastal wetlands, rivers and streams, shoreline landforms and human communities. As a result, they exchange materials and energy with these nearby ecosystems and play a role in maintaining the entire basin's ecological balance. In fact, virtually all species of Great Lakes fish use nearshore waters to sustain their critical life stages or functions. In addition, many ducks, geese, swans and other water birds feed and rest in the nearshore waters, especially during the fall and spring migrations. Endangered or threatened aquatic raptors, such as osprey and bald eagles, use the nearshore waters for nesting. Mammals and amphibians are found there, as well.

In technical terms, the boundary of nearshore waters is defined in terms of the shoreward extent of deep cold water which forms the summer thermocline, or boundary between cold dense water and the warmer surface waters. Mixing between the warm and cold water masses is very limited. Also, during the spring and early summer, pollutants are held close to shore by the thermal bar. This bar forms as water closest to the shore warms up and is prevented from mixing with water farther from shore because of density differences. Later in the season, warm water spreads across the lakes, but does not mix with the deep water until it cools in the autumn.

Because of limited mixing, inputs from the nearshore lands, wetlands, tributaries and ground water flow are concentrated in the nearshore. The nearshore waters are, therefore, the most vulnerable to pollution and other forms of ecological degradation. Organochlorine contaminants are found at unacceptably high levels in Lake Michigan and Lake Ontario. These and other industrial pollutants, including oils and metals, are at high levels in sediments in some connecting channels, and in certain harbors throughout the system.

Other human activities have taken their toll on the nearshore waters in a number of ways. Agricultural runoff from streams and shoreline has disturbed the chemical balance of the water by introducing excess nutrients, like nitrogen and phosphorus. The passage of boats for transportation during the winter has destroyed ice bridges used by mammals. Navigation-related dredging through 1972 moved 357.2 million cubic meters of sediment and other materials. Continued dredging removes about 4-6 million cubic meters per year.

Among the most destructive human activities for the nearshore waters have been power production and the introduction of exotic species. Billions of adult fish, eggs, and larvae are killed every year by being drawn into cooling water intakes of thermo-electric plants. At the same time, at least 139 new aquatic organisms have become residents of the Great Lakes since the early 1800s. Without natural predators, these exotic species, which are released from ships dumping solid or liquid ballast, rapidly reproduce and alter the biological state of the nearshore waters. For example, predation and competition by the alewife, which became established in the Great Lakes as early as 1873, suppressed native populations of yellow perch, emerald shiner, whitefish and spoonhead sculpin.

While there is little doubt that the nearshore aquatic environment of the Great Lakes has been changed physically, chemically and biologically by human activity, the trend toward worsening conditions has slowed down in the last 25 years and in the case of water quality has even been reversed. The overall reduction in the quantity of algae, and a drop in the annual occurrence of anoxic conditions in the bottom waters of central Lake Erie, indicate that the Lakes are returning to original conditions. This trend shows that the efforts to reduce nutrient loadings to the Lakes have been successful. Other indicators of the improving health of the nearshore waters are an increase in the population of burrowing mayflies, which are extremely sensitive to pollutants; a reduction in the number of beach closings; and the recovering fish community, including native lake trout, walleye, yellow perch and whitefish.

Determining the state of the nearshore waters ecosystem requires an evaluation of the ability of the living communities that make up that ecosystem to be self-sustaining with minimum human assistance. Unfortunately, there exists a lack of standard information on indicator species in the nearshore waters. To improve the monitoring of ecosystem health, information systems need to be improved.

Efforts to improve the health of the Great Lakes nearshore waters in the last few decades have made a positive difference. Continued vigilance is needed to prevent repetition of past problems. Coordinated management plans should be designed and implemented to protect wildlife habitat, fisheries, nest sites for aquatic raptors, tributaries that encourage native fish spawning, and water quality. Some habitat and biodiversity in the nearshore waters has been lost forever. But, as people become more educated about our impacts on the Great Lakes, the nearshore waters can once again thrive with a healthy variety of life and activity.

The Coastal Wetlands

Shaped by dynamic large lake processes, including waves, wind, ice and seasonal fluctuations in water levels, Great Lakes coastal wetlands are vibrant and unique areas of unrivalled importance to the life of the lakes. They are an essential component of the nearshore zone, and their protection is integral to the health of the entire Great Lakes ecosystem. In recent years, protecting wetlands has become a high environmental priority in both Canada and the U.S. Some information exists about individual wetland systems and dramatic improvements have been made in our understanding of the importance of wetlands and the ecological functions they serve. Yet, we still lack enough detailed and comprehensive information about the Great Lakes coastal wetlands to be able to report confidently on their current condition, trends in wetland viability and health, or the overall success or failure of current protection and restoration efforts. No inventory or evaluation system for measuring ecosystem health in coastal wetlands exists, and no system of classification of wetland quality has been commonly accepted. As a result, the state of the entire coastal wetlands ecosystem is not adequately known.

What we do know is that Great Lakes coastal wetlands are a considerable ecological, biological, economic, and aesthetic resource. Yet, these special ecosystems have been increasingly degraded and destroyed in the last century as a result of human activity. Most directly, the filling and dredging of wetlands to support human-desired land uses, such as agriculture, housing, industry, recreation, and commercial development, has reduced the number of wetlands in the Great Lakes basin. For example, researchers estimate 83 percent of the original 3900 hectares of westem Lake Ontario marshland has been lost forever, generally to urbanization. In addition, coastal wetlands have been harmed by other activities, including road construction; formation of break walls; introduction of non-indigenous species; the discharge of toxic chemicals; and changes in the lakes' water-level fluctuations. Reductions in water-level fluctuations and alterations of other natural physical processes are among the most serious threats facing remaining wetlands because such changes are not site specific and can upset the ecological balance of all coastal wetlands, regardless of whether or not they are protected from direct destruction.

In general, Lake Superior's wetlands, which are the most isolated from human impact, are in better shape than those of the lower lakes. Indicators of poor wetland health, including disruption of water flows, increases in exotic species, reductions in genetic diversity, and the presence of bioaccumulated chemicals in animal tissue, tell us where individual wetlands are in trouble. For example, the strong presence of invasive plants, such as purple loosestrife and the common reed, in Lake Ontario's wetlands suggests ecosystem stress, which may be the result of water-level regulation.

What we also know is that numerous species of fish, plants, reptiles, birds and mammals call the Great Lakes coastal wetlands their home, and for many of these species, these wetlands are their only home. Reptiles and amphibians breed, lay their eggs, and feed and raise their young there. Waterfowl, songbirds and shorebirds stop to rest and revive at Great Lakes wetlands on their long migrations. Small mammals, such as the muskrat and beaver, use wetland vegetation for food and shelter. Fish thrive in them. In fact, research shows that more than 90 percent of the approximately 200 fish species found in the Great Lakes are directly dependent on coastal wetlands for survival at some point in their life cycles.

In addition to providing a sanctuary for living communities, the Great Lakes coastal wetlands -- which include marshes, wet meadows, swamps, and peatlands -- play an essential role in sustaining the physical and ecological balance of the entire Great Lakes' Basin. A buffer between land and water, wetlands control sediment levels in the Lakes and river beds; they filter excess nutrients and chemical contaminants from passing water, thus improving water quality; they protect terrestrial systems from storms and erosion.

Human beings also benefit from the hard work of coastal wetlands. Many housing areas along the Great Lakes shoreline would be subject to the potential damage of wave forces, both on a regular basis and during storms, without the protective barrier that wetlands provide. The filtration functions of wetlands keep the Lakes water clean, thus preventing heavy algal growth and fish die-offs, which would make the area an undesirable place to live. Coastal wetlands provide humans a beautiful and peaceful place where they can bird-watch, photograph or study nature, or participate in hunting and fishing.

Luckily, it is not too late to prevent the total destruction of the coastal wetlands. Conservation, restoration, and stewardship can occur if planned carefully and undertaken with considerable attention paid to the interactions and interdependence between the uplands, the wetlands, and the lakes themselves. Wetland health must be monitored and measured using commonly accepted indicators, such as land-use patterns, wildlife population stability, vegetation richness, water levels, and water chemistry and composition. One powerful tool available today to assess the state of our coastal wetlands is remote sensing. With the advent of this technology, aerial photography and satellite imagery can determine the size and number of coastal wetlands and assess changes in wetland size as they respond to between-year water level fluctuations. Remote sensing also can measure land-use changes in the watersheds of coastal wetlands to find correlations between land use and wetland integrity. This correlation then can be used to determine policies to preserve our remaining wetland areas.

Policies for coastal wetland preservation and conservation rely on a wide range of tools to influence the fate of particular wetlands. These tools fall into four broad categories -- regulatory mechanisms, tax incentives, securement and stewardship initiatives, and special programs and partnerships. Wetlands are both publicly-held and privately-owned lands, and saving them requires cooperation between government institutions-- at local, regional and federal levels -- and American and Canadian citizens. We can choose to make changes that will preserve the Great Lakes coastal wetlands the way they naturally occur, thus ensuring that the intricate web of nutrients, sediments, plants, wildlife and water is maintained and sustained. Otherwise, we put an irreplaceable resource at risk.

Nearshore Terrestrial - Land by the Lakes

The land near the lakes, the nearshore terrestrial zone, is defined by the Lakes themselves. It is the product of ancient glacial sculpting; continuous etching by wave and wind; longshore currents; and the steady deposit of sediment by more than 500 tributaries all which constantly modify the 16,000 km of shoreline. The ever-changing shoreline, in turn, buffers inland, life-sustaining systems and interacts with coastal wetland systems. Nearshore terrestrial zones may be as narrow as a beach weathered by wind or as wide as a forest or dune field that extends many kilometers inland. They include unusual land features, such as the towering cliffs of Lake Superior's north shore and the stunning lake plain prairies of the Southern Lake Michigan basin.

Because climate, weather patterns, geology and soils vary throughout the basin, the ecological communities found in the nearshore terrestrial zone are incredibly diverse. Each Great Lakes near shore land type supports a plethora of plant and animal species, which, in turn, shape the land into identifiable ecosystems. Some of this flora and fauna can be found nowhere else in the world -- they exist only by virtue of the natural physical forces of the lakes. For example, the endangered Pitcher's thistle fights extinction on the beaches and dunes of Lakes Huron, Michigan and Superior.

After surveying the conditions of near shore lands and trends in conservation efforts throughout the lakes, researchers preparing for the 1996 State of the Lakes Ecosystem Conference have concluded that the health of the land by the lakes is degrading throughout the Great Lakes basin.

According to the background paper prepared for the conference, reversing this trend will require a concerted international effort to establish a core set of protected areas along the Great Lakes coast, and coordinated shoreline management measures elsewhere between these core areas.

Human activity can damage ecological health of the nearshore terrestrial zone in both direct and indirect ways. Direct damage comes from alteration through conversion of natural lands to areas or managed for agricultural, residential, industrial and recreational development; extraction of timber or minerals; and paving or armoring of shoreline to facilitate transportation or other water uses. Indirect damage occurs when human activity disrupts physical processes that sustain nearshore habitats. The release of toxic chemicals; the interruption or exaggeration of lake level fluctuations due to dredging, dams and canals; and the introduction of exotic plants into the food chain all upset these physical processes and damage the ecological balance of near shore lands.

In the SOLEC '96 paper, nearshore land areas are examined from three perspectives: as 17 geographic ecological regions which cover the area; from the perspective of 12 special ecological community types such as sand dunes that occur in one or more of the regions; and on a lake by lake basis for the 5 lake basins. The quality of each area or community is ranked based upon indicators.

Ecoregions were ranked from A to D based upon a set of factors. One area in the Lake Superior basin has an overall rank of "A" or relatively undisturbed while one area each in Lakes Michigan and Ontario together with two in Lake Erie are ranked as "D" or severely disturbed.

The 12 special lakeshore ecological communities were evaluated and rated based up on the percent of the community remaining in a healthy state, major stressors and sources of stressors, species and communities endangered or threatened, and stewardship indicators in place. .

The twelve special ecological community types represent some of the unique features of the Great Lakes nearshore lands. They are:

- Sand beaches are formed when waves and wind deposit sand eroded from other places on exposed shoreline. These beaches are important areas for migrating shorebirds to stop and feed on algal mats and a variety of microcrustaceans and insect larvae. Shoals, sandbars, and spits are specific types of sand beaches that protect lagoons and coastal marshes from wind and wave action. Rating C

- Sand dunes form where sand is abundant, the wind blows constantly and there is a place for sand to be deposited. They are continually reshaped over time and support diverse vegetation. Sleeping Bear Dunes National Lakeshore, Lake Michigan and Grand Sable Dunes National Lakeshore, Lake Superior are particularly striking examples of sand dunes. Rating D

- Bedrock and cobble beaches are rocky beaches shaped by wave and ice erosion. These rocky shorelines contain rare mosses, lichens, and thin-soiled plants. Acidic bedrock beaches intergrade into coastal gneissic rocklands in Georgian Bay. Rating D

- Unconsolidated shore bluffs are primarily composed of unconsolidated clay, till, or other sediments, and provide a fascinating geological record of the history of the area. Some shore bluffs, such as the Scarborough Bluffs on Lake Ontario, are home to rare plants such as Indian Paintbrush, Yellow Lady's-slipper, and Queen's Lady-slipper. Rating C

- The ancient acidic rocks of the Algonquin Arch are made mostly of a banded rock called gneiss. These areas thus make up the coastal gneissic rocklands and are home to several threatened species such as Prairie Warblers and Eastern Massasauga Rattlesnake. Rating C

- Limestone cliffs and talus slopes dominate the Niagara Escarpment. Extensive forests associated with the cliffs play host to many forest interior birds. The slopes themselves contain a mix of many rare and unusual species of plants. Rating B

- Lakeplain prairies consist of deep soil on which a variety of tall grasses and flowers grow. Some of the best examples of prairie are found along Saginaw Bay, western Lake Erie, and the St. Clair River Delta. Rating F

- Sand barrens are areas of deep sands with scattered oak and pine trees. They are defined by poor soils and frequent, intense fires. Both types of barrens are found in northern Wisconsin and on the southern and eastern Lake Michigan. Rating D

- Arctic-alpine disjunct communities are isolated pockets along the north shore of Lake Superior. These communities are home to rare plants adapted to severe weather and isolated, due to glacial retreat, from their primary range. Rating B

- Atlantic coastal plain disjunct communities occur only in sand or peaty shore with fluctuating water levels. Many of these plants are rare or threatened at the local level, and are vulnerable to shoreline developments and stabilized water levels. They are concentrated around the southern end of Lake Michigan. Rating C

- Shoreline alvars in North America occur only within the Great Lakes basin. They are naturally occurring areas of thin soil over limestone or marble bedrock. Many of the communities that alvar habitats support are considered by the Nature Conservancy to be globally rare. Major alvar areas include Corden Plains and Napanee Plains of southern Ontario. Rating F

- Thousands of islands exist within the Great Lakes. Because of their isolation, they are primary nesting sites for gulls, cormorants, terns, herons, and egrets. Islands are scattered throughout the Great Lakes. Rating C

In terms of rates of change, limestone cliffs were found to be improving and arctic alpine areas were found to be stable. In contrast, lakeplain prairies and shoreline alvars were found to be severely degrading. The 8 others were ranked as moderately degrading.

Each individual lake was also evaluated according to four indicators: loss of significant ecological communities and species, interruption of shoreline processes by lake edge armoring, representation of coastal biodiversity within protected and stewarded areas, and gains in biodiversity investment habitats protected through public ownership or policy. Lake Superior was rated "good" for all indicators except gains in biodiversity, while indicators for the remaining lakes were considered mostly mixed/deteriorating or poor.

Over all, the evaluation shows the land near the lakes to be significantly degraded and continuing to degrade. This lead the evaluators to conclude that existing efforts to protect the nearshore lands from the impacts of human activities are inadequate.

The authors of the SOLEC '96 paper conclude that the most pressing need is a conservation strategy for Great Lakes coastal areas that protects ecologically significant areas and restores degraded ecosystems back to health. A key element of this is seen to be focusing efforts to protect ecosystems within 19 geographic "biodiversity investment areas" which have exceptionally unique and diverse species, communities, and physical features. This would not be to the exclusion of protection and restoration of other areas.

The authors also conclude that an effective conservation and management plan for the nearshore terrestrial zone requires more than just the identification of threatened ecosystems to be saved. Education, public participation, partnerships with private landowners, information management, and cooperation between various agencies, governments and jurisdictions are essential for healthy management of the Great Lakes coastal lands.

Impacts of Changing Land Use

In the near shore zone of the Great Lakes nothing affects ecosystem health more than the way people use the land. In preparation for SOLEC '96, land use practices and trends were reviewed and evaluated for their impact on the nearshore areas of the lakes. The basic finding is that development of farm and natural lands in both urban and rural areas presents the single largest threat to the basin ecosystem.

Further findings are that land use in coastal areas of the Great Lakes is changing in response to the region's evolving economy and industrial restructuring as well as the relentless forces of urban sprawl. The aesthetic and recreational attraction of the shores is also spurring renewed public appreciation and use, in both urban waterfronts and rural locations.

Since the end of World War II, residential and commercial development has moved away from the city centers and into suburban areas replete with strip malls. The central cities with rail transportation and multi-story buildings have given way to truck transport, one story buildings, sprawling office parks and generally extravagant use of land. For example, in northeastern Illinois, residential land use increased by approximately 46% between 1970 and 1990 while population increased by only 4.1%.

This pattern has taken over vast stretches of land that were once either untouched or used for agriculture. A spread out community increases transportation and decentralizes industry. Where once there were enormous factories that stood several stories high, we now see low-lying buildings that cover the same area horizontally as the old ones did vertically. Former industrial areas abandoned in the move, now exist by the thousands as brownfields throughout the basin. Brownfields are empty and blighted, many housing sources of toxic pollution that thwart attempts to reclaim them for some practical use.

Sprawling growth is not limited to the major metropolitan areas, but is occurring around small towns as well, particularly where there are aesthetic attractions. The trend of our relatively prosperous society to commute increasingly far to work and to acquire second or "cottage country" homes is a management challenge for rural communities. They must trade off the benefits from new developments against the ecological impacts and other costs associated with growth or they must find ways to achieve sustainable growth. In areas of rapid growth, it is sprawl that predominates rather than more efficient forms of development. This form of growth results in greater conversion of natural habitat areas including wetlands, increased surface and groundwater pollution, and continuing air quality reduction associated with extensive use of auto and truck transport.

Agriculture also has a major impact on the land and water, covering 24% of the area of the basin. As populations have expanded, farmers have intensified their food production and changed the manner in which the soil is tilled. Erosion depletes the soil resource and causes problems in the water. It clouds the waters preventing sunlight from reaching submerged plants and injuring fish populations and the creatures they eat. It also buries valuable habitat.

Chemicals can also be a of concern. The World Wildlife Fund estimated 26 million kg of pesticides are used annually in the Great Lakes basin. Some of these chemicals are non-target specific and persistent, staying in the waters and the soil for a long time, possibly harming native plants and animals. Fortunately, usage of chemicals is declining due to the development of more effective, target-specific, and less persistent compounds and the adoption of innovative pest management strategies.

Farm animals can also cause serious impacts on land and waters. The domestic animal population in the Great Lakes basin produces an estimated 80 million tons of manure each year and has become concentrated in larger operations. Large amounts of manure from animal concentrations degrades water quality through runoff and related phosphorus loadings as well as nitrate leaching into groundwater. Although numerous farms reuse the manure for fertilizer, the production has far outstripped the need.

Each of these sources alone might not cause a serious impact upon the lakes. But when all of these them act in concert, there are serious implications for the land by the lakes. Water is being fed large amounts of nutrients from agricultural runoff. Toxins are leaching into the ground water from road ways and abandoned industrial sites. The shorelines are disappearing under armoring as new harbors and stormwalls are built. Individually, the resilience of the Lakes might be able to handle each problem. However it is the combination of all that is most destructive.

The SOLEC '96 background paper on changing land use evaluated several indicators related to categories of desired outcomes: efficient urban development, the protection of human health the protection of natural resources. Each of these was described in terms of their present state, the likely changes given current trends, the data used to evaluate these indicators and the quality of the data available. In general, most of the indicators were considered to be in mixed or poor condition with some trends improving. Those with improving trends include wastewater quality, air pollution levels, pollution prevention programs, and energy use. However, other indicators, such as traffic congestion, wetland habitat, and suburban land conversion, show deteriorating trends.

The SOLEC '96 paper on land use also suggests ways to develop more ecologically sound cities. Public transportation networks can be enhanced to reduce the number of cars on the road. Environmentally sensitive agricultural practices are being developed and can be adopted. In some Great Lakes harbors, such as Toronto and Cleveland , Ohio, redevelopment efforts along the harborfront are underway. New recreational, commercial, and residential uses for waterfronts and port facilities have revitalized the cities located along the coasts. Low-impact uses of shoreline land, such as recreational walkways or light commercial development, can improve both the urban and natural landscape. Land-use planners should look at such redevelopment efforts as models for the future.

In addition to these efforts, future land-use planning and development must become more creative, coordinated and regionally focused. In the United States, planning has traditionally been done at the local level, and neighboring municipalities sometimes have vastly different goals. As a result, U.S. efforts have been fragmented and disjointed. In addition, the present incentives of relatively low market prices for agricultural and natural lands, and the ease of conversion of those lands to other uses, encourage the low-density development of sprawl.

To preserve the Great Lakes nearshore ecosystem, an ecoregional approach to planning and development should be adopted. Conservation easements, the transfer of development rights, the purchase of development rights, improved transportation systems, cluster developments, financial incentives and new tax regulations all can be employed to make land use in the Great Lakes nearshore ecosystem more ecologically sound. Sustainable and regional land-use planning systems can control urban sprawl, enhance economic development, protect the environment and improve human quality of life.

Finally, improved awareness of the relationship between land use and the nearshore ecosystem through education and open public discussion is essential and a good starting point for the effort.

Information and Information Management

Although the Canadian and U.S. governments are committed to an ecosystem approach to management of the Great Lakes, without data to adequately assess ecosystems, the approach will falter. One of the most valuable functions of the State of the Lakes Ecosystem Conference is to bring this information together for people involved in Great Lakes decisions. The reports on nearshore waters, the land by the lakes, coastal wetlands and land use summarize and analyze available data on the nearshore zone. In addition, studies on everything from commercial fish harvests to drinking water quality are regularly conducted on both sides of the border. An extensive appendix that lists sources of known available information according to subject areas and sponsoring agencies or institutions is presented in the background paper on Information and Information Management prepared for SOLEC. The appendix describes the purpose and content of each database.

Timely access to reliable data is critical for determining not only the past and current state of nearshore ecosystems, but also for defining and achieving future ecosystem management goals. To be most useful for ecosystem assessment, data should be directly related to indicators chosen to reflect ecosystem states. Unfortunately, widely agreed-upon indicators for measuring the state of the nearshore do not exist. Such indicators would help define the type of information needed and enhance the value of the information for making decisions. Without those indicators, it is unclear what the data we do have tell us. Vast quantities of data do exist regarding the physical, chemical and biological components of the Great Lakes ecosystem, but for system-wide analyses data must not only give information that is ecologically relevant, but it must also be in forms which are consistent and comparable across the entire Great Lakes and over time. Yet because data have generally been collected for limited purposes by individual agencies, its value in system wide assessments are questionable. Two problems must be addressed: how to make the best use of available data to allow wise resource decisions, and how to insure that future monitoring and research are designed with the needs of an ecosystem approach to management in mind.

The optimal data for evaluating the nearshore zone would :

- be geographically complete;
- cover the entire Great Lakes nearshore area;
- be current;
- be part of ongoing monitoring programs which cover a long enough period to allow for comparisons over time and are regularly updated;
- be applicable, and collected to measure specific ecosystem indicators;

- be accessible and usable, having multiple applications related to several indicators.

Existing information was evaluated in preparation for SOLEC according to these criteria and found to be only "fair." Just a few data sets cover the entire Great Lakes shoreline. Most are lake specific. Data collected as part of coordinated binational efforts under the Great Lakes Water Quality Agreement (Lakewide Management Plans, Great Lakes International Surveillance Plan) are the most complete. Unfortunately, a number of these efforts have been ended in recent years, and few new Great Lakes-wide initiatives are in the offing. Some long term programs, such as water level monitoring are up-to-date, but much data are collected on a one-time basis for specific purposes, and quickly become out-of-date. In addition, since data are rarely coordinated with ecosystem indicators, their applicability and usability is only fair.

Even if standard ecosystem indicators could be selected and data gaps remedied, a daunting task remains: information management. Information management involves the collection, storage, manipulation and transfer of information and data. Today's age of fast computers and networking technology provides a means for accessing information instantly. Yet, anyone who has spent time surfing the World Wide Web knows that gigabytes of information in cyberspace do no good without the knowledge of what the information is all about and where or how to access them. This is especially true with scientific research.

Standard methods for collecting, storing and maintaining Great Lakes data should be developed and made consistent across a range of computer systems in use in the region. One way to do this, recommended by the SOLEC background paper on information management, is a database on the World Wide Web that contains references for all available Great Lakes data. The data itself need not actually be located there. Instead details about a data set or information holding, or "metadata" would be used. Decision-makers and scientists from all over the basin would then be able to query from their own offices and learn where information exists about a given nearshore topic. By forming a partnership using some already established web sites, such as the Great Lakes Information Network (GLIN) or the Great Lakes Information Management Resource (GLIMR), and the Great Lakes National Protection Office (GLNPO) website, data could be organized in such a way to make the task of protecting and understanding the Great Lakes more rational and manageable.

The information age offers an enormous opportunity for sharing, storing, collecting and analyzing scientific data. If people who manage ecologically relevant information throughout the Great Lakes basin can work with those who use ecosystem indicators to inform their decision-making, much more can be done to aid in the preservation and management of the unique ecosystems of the basin.