A PROSPECTUS FOR THE MANAGEMENT OF THE LONG POINT ECOSYSTEM

Great Lakes Fishery Commission

TECHNICAL REPORT No. 43

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A PROSPECTUS FOR THE MANAGEMENT OF THE LONG POINT ECOSYSTEM

by

GEORGE R. FRANCIS
Faculty of Environmental Studies
University of Waterloo
Waterloo, Ontario, Canada N2L 3G1

A.P. LINO GRIMA AND HENRY A. REGIER
Institute for Environmental Studies
University of Toronto
Toronto, Ontario, Canada M5S 1A4

THOMAS H. WHILLANS
Environmental and Resource Studies
Trent University
Peterborough, Ontario, Canada K9J 7B8

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Ann Arbor, Michigan 48105

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EXECUTIVE SUMMARY

A general approach for developing comprehensive ecosystem rehabilitation strategies for the Great Lakes was outlined in a previous study (Francis et al. 1979). This prospectus applies the approach in greater detail to the Long Point ecosystem on the north shore of Lake Erie. Long Point and its Inner Bay are not particularly degraded. However, this area was chosen because it is a fine location for determining how to adapt the approach to include sensitive dunes, savannahs, and marshes as well as near-shore aquatic ecosystems. This in turn would suggest the ecological bases for developing effective protective management strategies for the whole complex, and ways in which these may be incorporated into the existing institutional arrangements and management policies being applied in the Long Point area.

The geographic area of interest is first described with reference to its geomorphological features, biotic diversity, and history of human land and resource use over the years. A perspective for appreciating the extent of the impacts from human activities is given by tracing the accumulative changes in the land-stream-bay-lake continuum of the Long Point Ecosystem from pre-European times to the present. A list of 25 cultural stresses that are currently affecting this ecosystem was drawn up and ranked in the order of their perceived importance by scientists and managers.

A conceptual model for the Long Point ecosystem was developed using concepts derived from biogeography, trophic dynamics, and ecosystem stress-response analyses. The model distinguishes 20 distinct biotic communities based on field studies reported from the area. Energy and nutrient flows arising from wind, current, wave, and water-level variations are noted and the main cultural stresses acting upon each biotic community are identified. The model component for the grassy marsh biotic community was then elaborated in more detail. It is used to demonstrate different orders of food web interdependencies acting within this community and the cumulative impacts of four cultural stresses on these interdependencies. Besides serving as a means for organizing, integrating, and interpreting existing information and understanding of the Long Point ecosystem, the conceptual model helps direct attention to priorities for basic and management-oriented ecological research and environmental monitoring, and it provides a basis for organizing environmental assessment and management activities.

Because of the dominant role of government in the Long Point situation, analyses were made of governmental institutions and public policies which constitute the governance that has evolved for this area. A list of government institutions having formal responsibilities for the planning of sectoral or regional activities, funding remedial programs, enforcing regulations, directing resource

or environmental management, and providing for other supporting activities was drawn up for the 18 categories of ecosystem stresses described in the previous study (Francis et al, 1979). These institutional arrangements apply to the whole Canadian side of the Great Lakes. It was found that responsibilities for dealing with ecosystem stresses have been assigned to the IJC, GLFC, 12 federal departments, 9 provincial ministries, conservation authorities, regional governments, counties, and other local municipalities under some 64 federal and provincial statutes. An inner core group of 6 agencies was defined as those with regulatory or direct management responsibilities for 6 or more of the 18 stress categories. There appeared to be no major gaps in this standing structure of institutional arrangements for dealing with ecosystem stresses.

A compilation of 21 policy documents, which guide various resource and environmental management programs in the Long Point area itself, were reveiewed for their compatibility with the general approach espoused for ecosystem management strategies. Four basic goals and at least 20 objectives were identified in these documents. A set of key words or concepts was used to interpret which objectives were included or covered in each document. While the documents varied widely in their relative comprehensiveness and detail, this content analysis of them indicated a general convergence in their basic statements of intent and this convergence was compatible with rehabilitative management.

The actual program activities of government agencies in the Long Point area were described with reference to eight cultural stresses judged to have the most ecosystem effects. The overall impression from this review was that while the activities were for the most part quite compatible with ecosystem protection or rehabilitation, they were also very fragmented. Some seemed devoid of a shared perspective that might help bridge gaps in policies and programs and encourage more coherence among the various individual endeavors.

Management for the Long Point ecosystem raises questions about the allocation of rights and the policy instruments which could be relied upon for the ecologically sensitive management required. These questions were examined from a two-dimensional classification of rights viewed as exclusive or not exclusive and transferable or not transferable. Within the range of possibilities this reveals, 12 allocative mechanisms are identified. The current mix now being used differs from that of earlier times. It may soon shift away from an almost exclusive dependence upon administrative regulatory mechanisms. A critique is made of regulatory regimes generally, and with reference to an illustrative case example of the development of the Nanticoke industrial complex near Long Point. Other allocative mechanisms are assessed with explicit evaluative criteria. A preference is expressed for encouraging a larger measure of community-based, self-regulatory processes based on traditions of resource husbandry.

The main conclusion is that most of the substantive preconditions for effective ecosystem management exist in the Long Point situation. There is sufficient understanding, institutional capabilities, and commitment among key agencies to adopt and adapt the approach proposed by an ecosystem rehabilitation strategy. Some facilitating arrangements are nevertheless needed. These would encourage more information exchange and cooperation and seek to relate particular efforts to a more widely shared ecosystem perspective and management goals for the whole Long Point complex. Application of the concept of a "biosphere reserve" is proposed as one way to help bring this about. A guiding image of what is being sought is captured by alliteration: management of uses by users in the Long Point ecosystem must be sensitive, sustaining, sufficient, and systemic.

1. INTRODUCTION AND OVERVIEW

1.1 Background, Summary, and Conclusions

1.1.1 Background to the Prospectus Studies

In 1977 the Great Lakes Fishery Commission (GLFC) funded a feasibility study to review the state of the art for rehabilitating degraded aquatic ecosystems and to assess how this knowledge might be applied to the Great Lakes. The rehabilitation proposal arose as a result of the Second Canada-United States University Seminar of 1976-77 (Francis and Regier 1977). The study was of necessity broad in its scope. It addressed the three interrelated issues of the scientific and technical knowledge that can be applied to ecosystem rehabilitation, the socioeconomic benefits and costs associated with rehabilitation, and the institutional arrangements through which rehabilitative management would have to be carried out. Conduct of the study involved a critical review of an extensive range of literature supplemented by working group consultations, symposia, and workshops to test various ideas against specific and well-studied situations such as Green Bay on Lake Michigan and the Bay of Quinte on Lake Ontario. The general conclusion reached was that *comprehensive* ecosystem rehabilitative strategies for the Great Lakes are feasible to develop, and that it was timely to initiate them in selected nearshore areas where they can be tailored to particular conditions (Francis et al. 1979).

Follow-up work to develop specific approaches to help initiate rehabilitation planning and management was also funded by GLFC. Green Bay was one focus for a major case study (Harris et al. 1982). This bay was a particularly apt choice because of the extensive and intensive work related to rehabilitation that had been carried out under the Wisconsin Sea Grant Program and because of the strong commitment to rehabilitation shown by non-governmental groups associated with The Lake Michigan Federation. In Ontario, our interest shifted from the Bay of Quinte to Long Point on Lake Erie. Quinte was already the subject of a long-term monitoring experiment consisting of before and after studies designed to observe changes in limnological indicators and fish populations that could be associated with the introduction of controls on point sources of phosphorus such as municipal wastes. While these studies continued, the intent was to minimize other factors of change, such as additional management measures, to the extent that this was possible (W.J. Christie, pers. Comm.).

With respect to the Long Point ecosystem and its immediate environs, we have had some direct experience through field studies and recreational pursuits. H.A. Regier had studied this system on a recurring basis since the 1950s, and various colleagues and graduate students had studied aquatic aspects of the system in some depth. T.H. Whillans had been engaged for a decade with historic and recent studies of this ecosystem, especially with respect to its fish. In these respects, the Long Point ecosystem had some comparative advantages for us.

Long Point and its Inner Bay (see Fig. 2.1) are not particularly degraded. However, the Great Lakes Ecosystem Rehabilitation working group[1] was interested in adapting its approach to encompass the sensitive dune and marsh ecosystems as well as the near-shore aquatic ecosystems. We also wanted to determine how the approach might be used to develop sufficient strategies for the *protective* management of complexes not yet badly degraded. Interest in the Long Point area has been growing over the years as knowledge of the unusual mix of natural features found there has become more widely known. Concern has also been raised about possible detrimental effects arising from the slow but steady growth of the extent and intensity of human stresses on the ecosystem. These stresses are associated with the Nanticoke industrial development complex on the mainland nearby (see Fig. 2.2) and the associated possibility of accidental oil spills or other pollution events; with increasing water-based recreational activities; with changing agricultural land-use practices in the watersheds draining into the Bay; and with a general concern about the fallout of acids and toxic contaminants from the long-range transport of airborne pollutants.

Results from a number of field studies of the Long Point ecosystems undertaken over the past decade have been summarized and presented in several recent special publications (Barrett 1977; Whillans 1977; Nelson and Needham 1979; Federation of Ontario Naturalists 1980; Nelson and Jessen 1980; Hamley 1981; McCracken et al. 1981). An evaluative study had also been done on the environmental regulatory system developed in concert with the Nanticoke industrial developments (Nelson et al. 1981). Results of various other field studies, data analyses, and surveys have formed the basis of recent planning and management documents prepared by public agencies with administrative responsibilities for certain components of the Long Point area (Regional Municipality of Haldimand-Norfolk 1980; Canadian Wildlife Service 1983; Ontario Ministry of Natural Resources 1982, 1983).

Thus by the early 1980s, concerns about balanced development for the Long Point area were being expressed in a number of ways; the existing scientific knowledge of the area was being compiled, reviewed, and reported upon; and administrative authorities were preparing planning and management documents intended to guide resource and environmental management decisions for different components of the Long Point ecosystem. It was within this context that the perspectives brought by the Great Lakes Ecosystem Rehabilitation working group were thought to be a useful complement.

Our working group undertook to review the information about the Long Point ecosystem from the perspective that forms the central concept in its ecosystem approach, i.e., analyses of stress-response and recovery sequences. We undertook additional background studies on the institutional arrangements, policies, and programs through which a supporting rehabilitative strategy would

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1 The GLER Working Group at that time was co-chaired by H.J. Harris, University of Wisconsin, Green Bay, and G.R. Francis; Canadian members included the editors of this Prospectus.

have to be adapted, developed, and implemented. We helped organize two symposia dealing with Long Point: one in Toronto in January 1978 (Nelson and Needham 1979) and another in Waterloo in March 1980 (Nelson and Jessen 1980). In addition we held two informal seminar-workshops at Simcoe, Ontario, in July 1981 and at Jarvis, Ontario, in November 1982. These involved personnel from key public agencies to present ideas, discuss issues, and receive suggestions about the best way of proceeding.

Our intention generally was to direct more attention to the aquatic ecosystems that had been considered only tangentially by land-oriented planning and management agencies. We also provided an occasion for all groups concerned to consider the sufficiency of their collective efforts to protect the sensitive features and beneficial uses of all the component ecosystems. The introduction of the "stress-response" concept helped link resource and environmental management issues to related questions of economic development and land use.

1.1.2 Scope of the Prospectus

The geographic area of primary interest to us is centered on the Long Point formation and the Inner Bay between the Point and the mainland. It includes the Big Creek Marsh, Turkey Point Marsh, part of the Outer Bay, and waters of Lake Erie immediately adjacent to the Point. This is necessarily a rather arbitrary bounding of the Long Point ecosystem, which is in fact open to a number of external influences.

In Chapter 2 we provide a descriptive analysis of the Long Point ecosystem. We include an overview of the historical ecology of the area, we analyze the main stresses impacting the various component ecosystems, and we present a conceptual framework that helps integrate current understanding about the area in a manner that can help guide management-oriented research and the development of ecosystem management strategies.

In Chapter 3 we consider the present policies, programs, and administrative arrangements as they pertain to ecosystem management strategies. We review the existing standing structure of agencies and their mandates at the different levels of jurisdiction; we discuss current policy goals and on-going programs of agencies with reference to their compatibility and sufficiency for managing the set of interrelated ecosystems; and we review recent literature on policy instruments and issues concerning the implementation of management measures.

Chapter 4 outlines a general image of what an ecosystem rehabilitation approach might bring to the Long Point area. We show how a strategy based on this approach could be meshed into on-going activities of different agencies and outline the concept of a "biosphere reserve" as a useful device to help bring together all concerned to consider their activities in the context of the larger interrelated set of ecosystems. We conclude with a discussion of goals and directions.

1.1.3 General Conclusions and Follow-up

The general conclusions of these studies and the informal consultations undertaken in association with them are that most of the substantive preconditions needed for effective ecosystem management exist in the Long Point situation. There is sufficient understanding, institutional capability, and commitment among key individuals, agencies, and groups to adopt and adapt this approach to complement and help strengthen the on-going work.

Some concerns and uncertainties persist. These include management of various recreational uses affecting different component ecosystems, such as trampling sensitive dunes, dredging access channels through nearshore wetlands, and heavy fishing pressures on the Inner Bay itself; the need to alleviate stresses associated with soil erosion and non-point source pollution from some agricultural activities and urban development in the watersheds draining into the Bay; concern about the sufficiency of contingency measures to deal with possible accidents or spills from ships serving the Nanticoke industrial area; and concern about long-term effects of potential diversions, increased consumptive water use, and climate change on water flows, water levels, and wetlands. The first step is to strengthen the cooperation among key planning and management agencies and resource user groups. Their first challenge is to collaborate on developing an integrated interpretation of information concerning the entire complex of the Long Point ecosystem. This interpretation will be the basis for agreeing upon the shared monitoring of fluctuations, trends, and associated ecological changes. The needs and opportunities for ecosystem monitoring are currently addressed by no single agency or combination of them.

Twenty years ago the general public was told that Lake Erie was "dying." However appropriate or inappropriate this metaphor was to describe the deteriorating condition in some parts of the Lake through eutrophication and contamination, it did succeed in mobilizing the political will to respond. Through the considerable work carried out under the Great Lakes Water Quality Agreements of 1972 and 1978, some of these degrading stresses have been slowed or reversed. The contaminant problem in various guises (long-range transport of airborne pollution, re-mobilization of sedimented contaminants, leaching from land-fill sites, and improper industrial and domestic (pesticide) waste disposal) is largely unresolved.

Against this background of experience, the desirability of protecting ecosystems against degradation through preventive measures is obvious. The most cherished areas, such as the Long Point ecosystem, deserve the necessary attention to halt degradation stresses as early as possible through protective management measures by all concerned. The Great Lakes Ecosystem Rehabilitation working group hopes that this prospectus will contribute towards this goal.

2. THE LONG POINT ECOSYSTEM COMPLEX

2.1 Geographic Area of Interest

2.1.1 The Ecological Complex and its Setting

The area of particular interest to us is focused directly on the Long Point sand spit complex and the waters of Long Point Bay adjacent to it. It includes the

Big Creek Marsh, the Turkey Point Marsh, all of the Inner Bay, portions of the Outer Bay, and the waters of Lake Erie immediately adjacent to the exposed south shore of the Point. Hence the Long Point ecosystem, as we define it, consists of the rich mosaic of dunes, forest, wet meadows, and marsh on the Point itself, the waters of Lake Erie adjacent to it up to a depth of about 10 m, and the area enclosed by the Point and the 100-year flood height on the north shore of Lake Erie from the Big Creek marsh to Turkey Point (Fig. 2.1). The 10-m depth contour is approximately the top of the summer thermocline in this part of Lake Erie, and it also is an approximate outer limit of the active zone of erosion and sedimentation processes. The 100-year flood line, which has been mapped and acknowledged under municipal zoning policies, represents an upper boundary for lake-level fluctuations combined with storm events.

Of necessity, this is an arbitrary delineation of the geographic area of interest. The Long Point ecosystem so defined is open to a number of external influences: (1) its very continuance is dependent on the longshore flow of sediment from the west; (2) it receives sediments, nutrients, and some contaminants from the Big Creek and other watersheds flowing into the bay; (3) it has an open exchange of waters with Lake Erie that is an integral aspect of the dynamics of the Long Point ecosystem; and (4) it is part of a vast airshed in which many materials are transported to be deposited eventually in land and water.

The mainland region adjacent to Long Point can be defined by its watershed boundaries and, for certain purposes, by its municipal boundaries (Fig. 2.2). The physiographic region represented by the watersheds flowing into this part of Lake Erie come under the jurisdiction of the Long Point Region Conservation Authority. The municipal boundaries that best approximate the adjacent mainland are those of the Regional Municipality of Haldimand-Norfolk.

The Regional Municipality had a population of about 89,500 in 1981; about 58% were rural residents. The region can still be characterized as rural-agricultural, producing a wide variety of fruits, vegetables, and field crops as well as beef, dairy, and other livestock products. Its 3,900 farms had some $281 million in sales in 1981 (Ontario Ministry of Agriculture and Food 1982). A considerable potential for urban-industrial growth centers on the Nanticoke industrial complex, at the core of which is a coal-fired electrical generating plant with 4,000-megawatt capacity; a steel plant with an annual capacity of 1.35 million tons; and an oil refinery capable of producing 105,000 barrels per day. Although economic growth has been slow in recent years, this potential for development has helped to strengthen a local concern and determination that it not result in the degradation of the most valued, sensitive features and uses of the Long Point ecosystem.

2.1.2 Geomorphological Features, Natural Variations, and Biotic Responses

Long Point merits its name; it is the longest sandspit formation in the Great Lakes, reaching some 34 km into Lake Erie. Historically, it was at times a peninsula, at others a series of closely linked islands and shoals. This system is a product of past events and processes and is still affected strongly by factors external to it. It self-regulates to some extent and has developed its own distinct ecological personality.

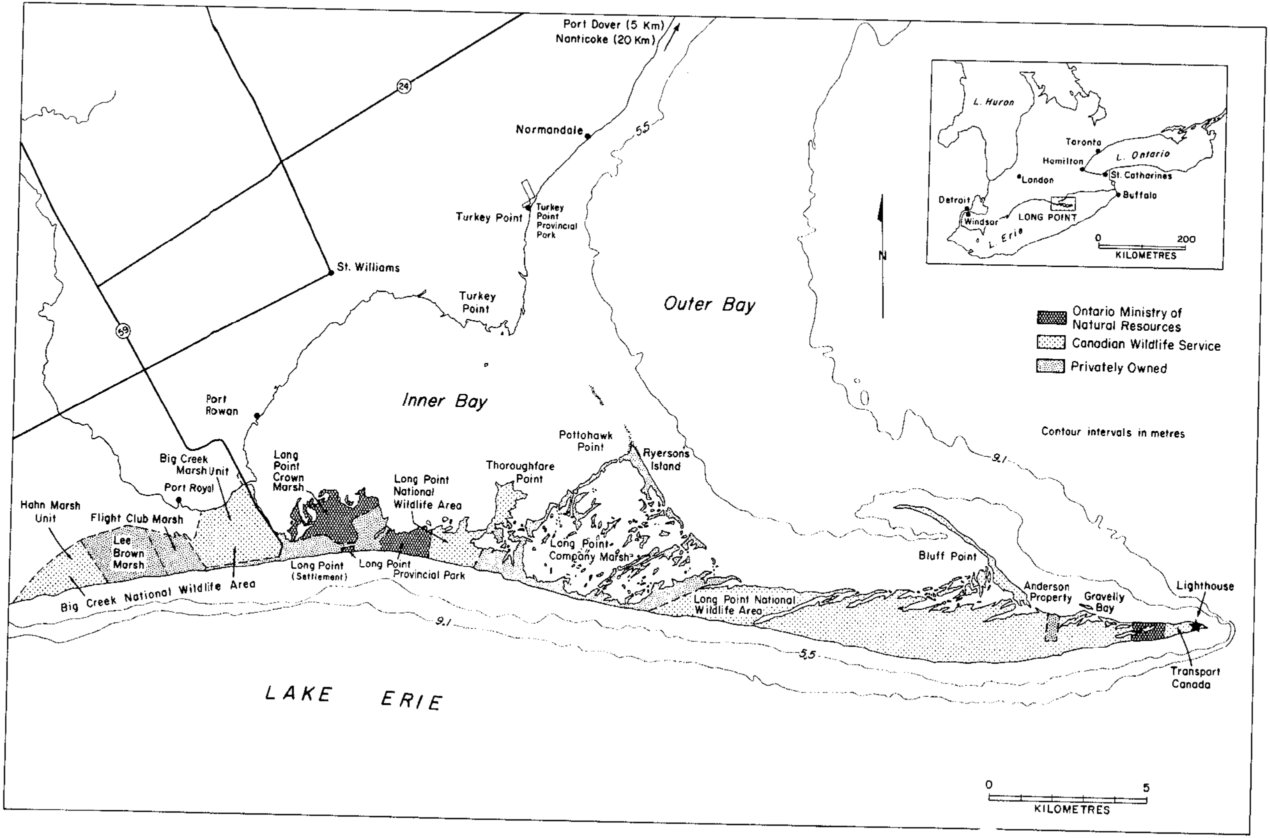

Figure 2.1 The Long Point area

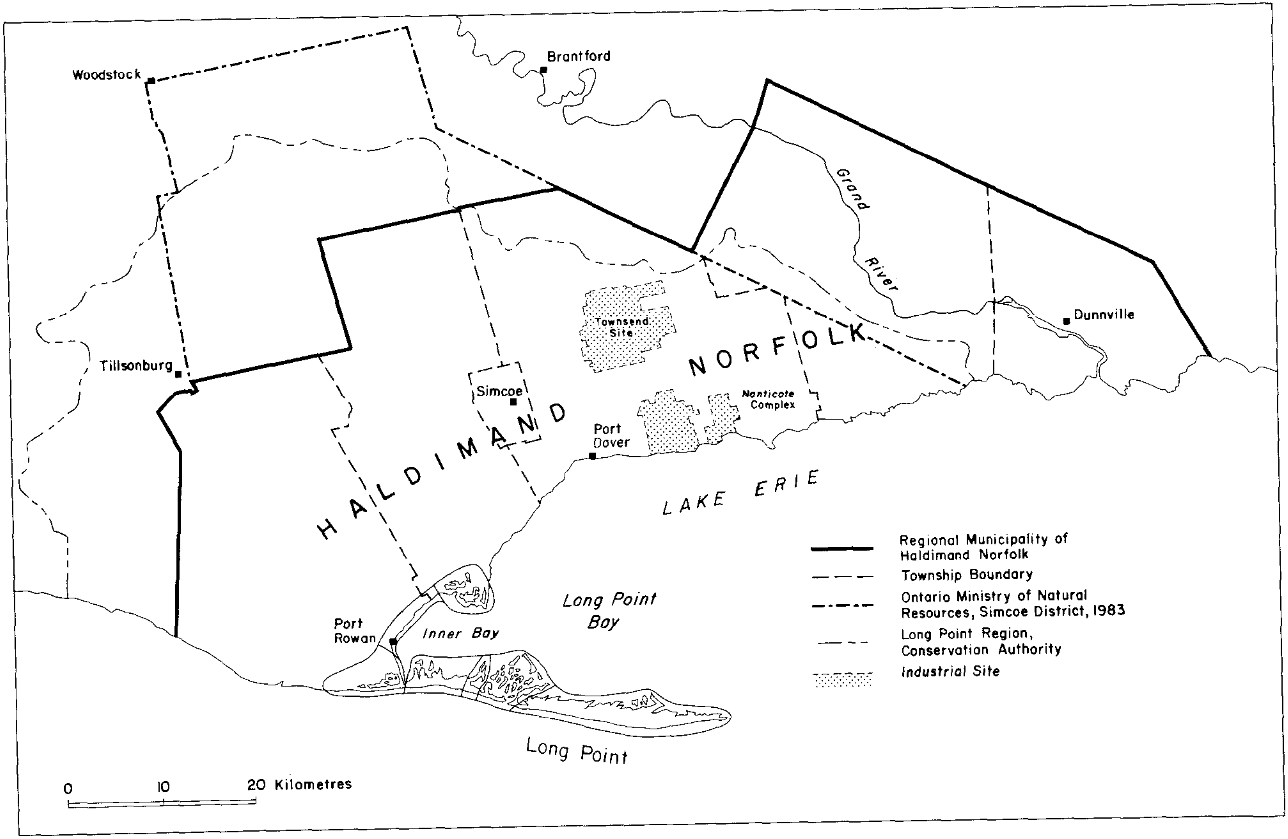

Figure 2.2 Administrative divisions of the Haldimand-Norfolk region

The Lake Erie shoreline is still recovering from the glacial ice of Wisconsinian times that covered the Great Lakes Basin until some 12,000 years ago. Long Point began forming when the shores of Glacier Lake Warren coincided with those of Lake Erie some 4,000-5,000 years ago (Chanasyk 1970). Its initial formation came from reworking a moraine that was depostied by the retreating ice. Long Point lies on the northern edge of the Appalachian Geosyncline, and is composed of glacial tills, lacustrine sands, and clays overlying Devonian bedrock (Heathcote 198 1).

The sand that comprises Long Point and a large region underlying it originated from the Norfolk sand plain. The plain is the delta of a river that flowed into glacial Lakes Whittlesey and Warren more than 32,000 years ago (Coleman 1922; Chapman and Putnam 1973). Long Point itself has been maintained and shaped over the past 4,000 years mainly by eastward flowing longshore currents of the Central Basin of Lake Erie. Erosion of shoreline and bluffs west of Long Point, as far as Rondeau over 100 km away, is an important source of sediment; an estimated 1.37 million m^3 per year are carried to the Long Point spit (St. Jacques and Rukavina 1973; Heathcote 1981). As a result of this availability of sediments and the high wave-energy levels, the Point builds constantly to the southeast at an estimated 7 m annually. Sediment is also added to the ecosystem from the watersheds of Big Creek and Dedrick Creek, draining some 730 km^2 and 81 km^2, respectively.

The Inner Bay, as the name suggests, is a relatively shallow embayment. Its morphology has varied considerably because of occasional breaching of Long Point by storm and wave action, especially during high water levels in Lake Erie. The surface of this bay is about 68 km^2, and maximum depths ranging between 1.6 and 12.3 m have been recorded at various times since 1790 (Whillans 1979a). Water levels in the bay fluctuate closely with those of Lake Erie and are subject to seiche action (Berst and McCrimmon 1966). The erosion and deposition processes occurring in Long Point Bay are causing a gradual coming together of Turkey Point with Pottahawk Point on Long Point, as water-carrying sediment from Big Creek meets currents circulating in the Bay. A sandbar is forming that distinctly demarks the Inner Bay from the Outer Bay.

Generally, the Long Point ecosystem experiences a moist continental climate moderated by the Lake. Prevailing winds over the Point average 10 km per hour and are mostly from the south and west (Kohi and Faroogni 1980). The mean annual precipitation at St. Williams on the adjacent mainland is 99.8 cm recorded at an altitude of 213 m. Thunderstorms and fog are frequent at Long Point. Ice forms extensively in the bays and contiguous basins of the lake, commonly with an area of open water southeast of the tip of Long Point (Heathcote 198 1).

These geomorphological and climatic influences have created opportunities for biotic development. The west winds, which contribute to the eastward longshore currents of the Central Basin, are also responsible for the relatively harsh aquatic and terrestrial environments along the south shore of Long Point. Sparsely populated communities of specialized organisms exist there. The lake-moderated temperate (moist continental) climate has fostered establishment of vegetation communities well-endowed with Carolinian-Alleghanian plants and associated animals, many unusual in Canada, in upland areas of Long Point and the adjacent mainland. Sheltered shores of the Inner and Outer Bays are subjected to long-term, annual, and seiche water-level fluctuations. Extensive marshes and some swamps are present. Where organic matter has accumulated and hydrological conditions are little influenced by watercourses, fens and bogs have developed. These products of long-term processes have provided refuge for some boreal species. Imposed on this background, periodic storms have had major influences on the physiography and biotic communities in the Long Point ecosystem, as described below.

Two hundred years ago, when human impacts on the Long Point ecosystem were small, natural events nevertheless occurred which disrupted the ecological association, at least locally. Because Long Point is an erosional depositional feature, the biotic communities that it supports or shelters are mainly successional in that they are characteristic of ecological recovery that follow ecologically destructive events.

Ecosystems built on sand are disrupted rather readily. Disruptions were subsequently followed by a recovery sequence of ecological succession in which the anchoring capabilities of plants were very important. It seems likely that the ecosystem as a whole was never in a state of static climax but always in process toward climax through recovery from the inevitable setbacks of natural events, and also from the setbacks caused by the relatively few Indians present.

This does not mean that at any given time existing special and pleasant features of the system are doomed to short life. It does suggest that the processes of erosion and deposition, partial natural destruction, and subsequent successional recovery must continue if those preferred features of such an ecosystem are to be perpetuated. In a real sense, erosional and depositional features result from flow-through processes and successional features are outcomes of rejuvenating processes. The rate of erosion and deposition varies with the height of water level, degree of recession of eroded shoreline, and degree of incision of upland areas. Thus the fate of Long Point is tied to the erosive state of the Norfolk sand plain and modified by the hydrologic regime, especially water levels, of the Great Lakes.

The bluff and stream erosion that now serves to perpetuate the Long Point and Turkey Point peninsulas derives from unvegetated lakeshore bluffs, catchment slopes, and stream banks. In ecological perspective these eroding locales are highly disturbed, to the point at which no permanent vegetation can grow on them. Also, turbidity from erosion into watercourses shades out sunlight necessary for development of macrophyte beds and stands. Where the eroded materials are sedimented, the bottom organisms are challenged by the material loaded onto them. Nevertheless, the ecological association compensates, adapts, and recovers from the adverse concomitants of a process essential to this kind of aquatic system. Beach nourishment from bluff and stream erosion compensates for loss of beach sand to the deeper parts of the lake.

Thick ice forms in Long Point Bay, especially in severe winters. In shallow waters and wetlands, the frost may penetrate into the sand and muck. If the water level then rises, it may cause the ice to float, tearing out the adhering frozen substrate and its wetland association, usually in small locales. The ice may be moved laterally, perhaps toward the bank, before thawing. The organisms and the other material may be deposited in strange surroundings, leaving behind denuded or excavated spots. A local succession develops in response to such a perturbation.

The width of a wetland association in a protected bay is related to the amplitude of the long-term cycle of water-level fluctuations, as already indicated. As the water level rises, the whole association migrates in an inshore direction. Animals can move, of course, but few individual plants have that capability. Thus migration in the case of higher plants involves the death of those that find themselves in water of inappropriate depth and enhanced recruitment of young plants at a new site of appropriate depth. There is obviously a time lag involved, and this mechanism would not be effective as an adaptation to markedly fluctuating water levels when these occur quite frequently. Any wetland association of macrophytes would find rapid, large water-level changes inhospitable, and the shoreline would exhibit little ecological organization.

Succession and the state of a biotic community are not, however, completely explained by the nature of the climatic events or other disturbance which initiates or perpetuates it. The types and condition of biota that are present are important. For example, in a disturbed wetland community, seed banks or links to plant refuges will have a major effect on the successional pattern of plants in the community. The mainland and Lake Erie have served as refuges for biota disturbed in the Long Point ecosystem.

The natural history requirements of biota may predispose a system to successional change. Resident species in the Long Point ecosystem often roam to locations outside of the system for important life cycle functions. Thus raptors and stream-spawning fish share a need for undisturbed environments external to this ecosystem.

Biota with an ability and opportunity to invade a system may also initiate successional change. Coyote and other species have made recent inroads. Similarly, the Great Lakes have been invaded by aquatic organisms such as Eurasian milfoil and white perch. In other systems such biota have had major impacts.

2.1.3 Biotic Diversity of the Long Point Ecosystem

Long Point maintains a rich mosaic of habitats including beaches, sand dunes, grass-covered ridges, wet meadows, woodlands, marshes, and ponds. The Big Creek marsh is mainly wet meadows with some open channels, beach, and shrubby edge habitats. The waters of Long Point Bay are the only nearshore waters in Lake Erie classified as oligo-mesotrophic; all others are mesotrophic to eutrophic (Heathcote 1981).

Habitat diversity is reflected by the associated plant communities. These have been described at different levels of detail by Heffeman and Ralph (1978), Bradstreet and McKeating (1981), and Catling and Reznicek (1981). The dominant terrestrial vegetation has a distinct Carolinean-Alleghanian affinity that reflects the southern location of Long Point combined with moderate climates. The flora of Long Point comprises some 700 species of plants. About 90 of these are rare in Ontario and at least 4 occur nowhere else in Canada (Catling and Reznicek 1981).

The plant communities of Big Creek marsh are composed of extensive stands of cattails with other rooted aquatics and some floating macrophytes. Marsh emergents show vigorous mosaics of stands dominated by single species such as various sedges, reedgrass, cattail, and wild rice (Bayly 1979). Habitat mapping of the marsh indicated that the Big Creek vegetation may have been in this marsh meadow state for some time (Hardy 1979).

Berst and McCrimmon (1966) estimated that about 90% of the bottom of Inner Bay was covered with aquatic vegetation which included, in order of abundance, species of stonewort, wild celery, pondweed, naiad, and waterweed. Smith (1979) found that stonewort and Eurasian milfoil were the predominant species in sand and loam sediments. Wild celery, slender naiad, and Eurasian milfoil were most abundant in muddy areas (Leach 1981). Dominant algal genera include Cladophora and Ulothrix (Nanticoke Environment Committee 1978).

The marshlands and nearshore waters of Long Point are areas of continental significance for migratory birds. They are important staging areas for a number of species of waterfowl (Dennis and Chandler 1974; McCullough 1981) and a large proportion of the continental populations of canvasbacks and tundra swans pass through the area each year (Bradstreet and McKeating 1981). Several thousand waterfowl commonly winter in the Long Point area. Large numbers of non-game birds also concentrate on the Point during migration periods. Since 1960 the Long Point Bird Observatory has banded over 227,000 birds representing 239 species (McCuaig 1981; Smith 1983). Of these, 148 species breed or summer at the Point (McCracken et al. 1981).

The Inner Bay harbors most species of Lake Erie fish during one or more stages of their life cycle (Whillans 1979b). The Long Point ecosystem provides important spawning and rearing areas for largemouth bass, smallmouth bass, yellow perch, and northern pike. An extensive sports fishery has developed (Hamley and McLean 1979) and there is one documented report of over 3,000 anglers on Inner Bay on opening day of the bass season (Stanley 1978).

Commercial fishing is largely restricted to areas outside of the Inner Bay. Rainbow smelt and yellow perch are the two most important species harvested, and the Outer Bay fishery operating out of Port Dover accounts for most of the smelt harvested in Lake Erie. Fishermen also use hoop and seine nets in designated portions of the Inner Bay to harvest an annual average of 167,000 kg of coarse fish (Demal 1977).

The biotic diversity of Long Point is also reflected by over 25 species of fish found in the lakeshore lagoons (Mahon and Balon 1977). The lake chubsucker, pugnose shiner, and yellow bullhead are three species found in Long Point that are listed as threatened in Canada (Canadian Wildlife Service [CWS] 1983). The herpetofauna of the Point is quite rich for a Canadian locality, and includes at least five species that are rare or threatened (CWS 1983). The mammalian fauna on the whole is less distinctively different from elsewhere in southern Ontario.

However, the invertebrate fauna may exhibit some unusual species occurrences based on fragmentary information available.

2.1.4 Human Influences and Values in the Long Point Ecosystem

The Canadian Lake Erie basin and perhaps the Long Point ecosystem have been used by humans for about 12,000 years and perhaps in previous inter-ice age periods (Brose 1976). The shores of Inner Long Point Bay and lower reaches of rivers draining into it are particularly well endowed with late Woodland, early Ontario Iroquois sites (A.D. 700-1650). Abundant fish bones and net remnants indicate that many of these were fishing camps. It has been suggested that one village 3.2 km upstream on Dedrick Creek achieved an unusually large size because of the rich biotic food resources around Long Point Bay (Fox 1976).

Heaviest human use of the Long Point ecosystem has occurred more recently. Land clearing and deforestation of the Long Point Bay drainage basin began in the 1790s intensified in the 1840s and peaked between 1860 and 1880 (Whillans 1979b). Long Point itself was initially logged in the 1860s and again periodically until 1951 (Heffeman and Nelson 1979).

Agriculture was practiced throughout the 1800s in cleared and natural upland and wetland meadows in the Long Point ecosystem. On the mainland, wheat, rye, barley, buckwheat, oats, peas, corn, and some fruits were produced (Blake 1963). Fruit trees and vegetables were grown along several sand ridges on Long Point (Barrett 1977). Cattle and horse grazing were extensive, particularly utilizing natural bluejoint reed grass in Turkey Point, Big Creek, and Long Point marshes and also upland hay (Blake 1963). By the turn of the century, however, much land was abandoned because of depleted soils and wind and water erosion.

Reforestation was initiated in upland areas of the mainland in 1908 and tobacco farming began in 1926 (Barrett 1981). Since then, land use has changed markedly. Agricultural activities in recent years have produced corn, rye, oats, wheat, hay, fruit, vegetables, livestock, poultry, and dairy products in addition to tobacco (Chapman and Putnam 1973). Forest cover is now generally greater than 10% in the area that drains into Inner Bay and exceeds 20% over much of that area (Ontario Ministry of Natural Resources 1983). Erosion from farms has been reduced substantially since early in the century. Annual suspended sediment yield for the agricultural watersheds draining into Long Point Bay ranges from 100 to 225 kg/ha. This is the lowest of all Canadian watersheds draining into Lake Erie, excepting the upper Grand River (Wall et al. 1982). The annual suspended sediment yield from Long Point, however, ranges above 600 kg/ha and ranks with the highest in southern Ontario (Wall et al. 1982).

The Long Point ecosystem remains essentially rural. Upland areas are farmed or are in woodlots. Some agriculture is practiced in dyked marsh, conspicuously in Turkey Point Marsh. The main intensive use of wetlands is for recreation and recreational service. Two Provincial Parks, two National Wildlife Areas, and a Provincial Wildlife Management Area exist in or extend into the Long Point ecosystem. Three small towns are on the mainland at or close to the ecosystem: Port Rowan, St. Williams, and Turkey Point. A cottage community also exists at the base of Long Point itself. The Nanticoke industrial complex is situated on the mainland immediately north and some 25 km from the outer reach of the Point itself.

Much of Long Point itself was sold by the government of the day to a private hunt club, the Long Point Company, in 1866. The club kept its holdings as an exclusive reserve for waterfowl hunting by its members; the arrangement continues to this day. In 1979 about half of the Company's holdings were turned over to CWS with a legal covenant requiring the lands to be protected from human disturbance to the greatest extent possible. It is this history of private protection for over a century that has led to the preservation of so many of the natural features found today in the Long Point ecosystem.

The main tributary to the Long Point Region, Big Creek, once flowed westward at Long Point's base, into the Central Basin of Lake Erie. In 1860 the mouth of the Creek was diverted into the Inner Bay and maintained until 1876 (Jost 1943). A natural gap then existed at the base of Long Point. The gap plus the diversion resulted in advantages to the lumbering export trade which focused on Port Royal, just south of Port Rowan (Overton 1970). A consequence of the diversion was that sediments eroded from Big Creek were not carried to the lakeward side of Long Point but were deposited into the wetlands of Inner Bay. This resulted, so far as can be determined from palaeolimnologic evidence, in an increased rate of infilling of Inner Bay and expansion of Big Creek Marsh (Whillans 1985). Such infilling would necessarily increase turbidity in the Bay. Channels and harbor areas were dredged at Port Royal, Port Rowan, and adjacent to cottages and marinas periodically between the 1960s and present (Whillans 1977). The immediate effect was to reduce the area of macrophyte beds and stands, first through deepening but also through covering of nearby areas where the dredge spoils were dragged or dumped.

In 1929 a causeway was constructed along a series of sandy hummocks through the marsh from the base of Long Point to the higher sandy portions further out on the Point (Whillans 1985). The causeways served as a base for a Highway 59 extension onto the Point. Material for the causeway was taken from a borrow pit less than 1 km north on Highway 59 or dragged from the marsh. The causeway altered the hydrological flow patterns, especially during floods. Extreme channelization had occurred by the 1940s when all but one of Big Creek's routes through the causeways had been filled in (Whillans 1985).

Access to the sandy ridges of Long Point by the causeway made the point a desirable place for summer cottages. These were constructed in wetlands or near the water along the south beach at the base of the point. Usually such areas were first filled in to bring them safely above high water level. The infilling covered up the wetland association and reduced its area, attendant productivity, and its role in the Inner Bay ecosystem. Human refuse and wastes inevitably found their way into the aquatic system. Local sources had minor effects (Bayly 1976).

Lake Erie in general became polluted and degraded through the loss of valued sensitive organisms and the invasion or expansion of less valued tolerant species (Regier and Hartman 1973). Fishing had a number of direct and indirect effects. Commercial and sport fishermen generally preferred the large species that also happened to be sensitive to disruptions of the ecosystem-whether caused by nature or by humans. These preferred species eventually became less abundant, especially the old and large individuals. Some smaller species became more abundant. Anglers also needed docking and parking facilities with a resultant loss of shore and wetland habitat. Seine fishermen cleared obstacles from the area to be seined and constructed onshore facilities and devices for operating the seines.

The five examples of human activities sketched above began to influence the Long Point ecosystem's aquatic components soon after settlement by Europeans. Some of the early activities had long-term consequences, as shown above. Many other activities also had adverse impacts, as will be elaborated further in the next section.

If humans were to cease influencing the Long Point ecosystem, almost all the effects now so obvious would wane over the ensuing few centuries. Brick and stoneworks of various kinds would litter the landscape, Big Creek would likely reestablish outlets through the causeway or south beach, and boating channels would fill in. The Long Point ecosystem would revert to a natural system, adapting to natural events and maintaining its self-regulatory capability.

Every ecosystem is in some way unique and valuable. To a certain extent these qualities bear personal meaning. Some ecologic values are known; others, like many social values, are unrevealed (unmeasured or intangible; Talhelm 1982). Social values are, however, expressed clearly in official documents such as The Official Plan for the Haldimand-Norfolk Planning Area (Regional Municipality of Haldimand-Norfolk 1980) and the Simcoe District Land Use Guidelines of the Ontario Ministry of Natural Resources (OMNR 1983).

The Official Plan for the area identifies the following normative principles that relate especially to the Long Point ecosystem:

- preserve agricultural, rural, and traditional ways of life;
- prevent unsafe use of hazard land;
- protect environmentally sensitive areas, including Long Point, Turkey Point, and Inner Bay (designated as Provincially Significant Areas);
- maintain and rehabilitate hydrologic functions;
- minimize noise;
- minimize exposure to harmful pollutants;
- ensure that extraction of mineral resources is done sensitively;
- maintain and expand forest cover;
- rehabilitate commercial and sport fisheries;
- control private and improve public access to lakeshore;
- increase recreational opportunities; and
- conserve heritage features and foster public awareness of these.

The OMNR land-use guidelines complement many of these principles with more specific targets for the natural and harvestable resources of an area that encompasses the Long Point ecosystem. Potential realized values for the area include

- about 125,000 m^3/yr of forest products from Simcoe District (by the year 2020);
- 6,000 deer and 83,000 small game hunting opportunities annually, mostly in mainland areas;
- waterfowl viewing, 46,000 waterfowl hunting opportunities, and 16,000 fur pelts annually, mainly in marshes around Turkey Point, Long Point, and Big Creek (but also elsewhere);
- 5,500,000 kg/yr of commercial fish from Inner and Outer Bays;
- 242,000 sport fishing opportunities per year, mainly within the Long Point ecosystem; and
- 11,200 day-use experiences and 100,000 camper nights in Turkey Point and Long Point Provincial Parks.

These values are readily acknowledged because they represent products of the Long Point ecosystem and adjacent areas. Other valuable features of the ecosystem that derive from their uniqueness include

- Long Point and Turkey Point spits and scenery;
- the unusual mix of habitats;
- 60 provincially rare and 90 regionally rare plant species (Catling and Reznicek 1981);
- a continentally significant staging area for migratory birds;
- an estimated 115 species of nesting birds, of which 98 are confirmed (McCracken et al. 1981);
- unusual invertebrate inhabitants (i.e., meadow crayfish) and migrants (monarch butterfly); and
- five species of rare or threatened herpetofauna (Bradstreet and McKeating 1981).

A complete list of all of the perceived values of the Long Point ecosystem would be difficult, and perhaps not possible to compile. However, a sufficient number and variety of values have been widely recognized for it to justify a continuance of sensitive protective management for this special ecosystem.

The Long Point ecosystem has escaped the major aquatic degradation of western Lake Erie and has not yet been severely degraded by urban and industrial development that is encroaching from the east. Large portions of this ecosystem have, as private fish and wildlife reserves, been preserved from cultural transformation. The Long Point ecosystem is one of the few in the lower Great Lakes where natural processes and landscapes remain prominent. Curiously, it was one of the earliest areas in Ontario settled by Europeans. The heritage of relatively sensitive forestry, agriculture, fishery, wildlife husbandry, and natural interests is appreciated locally.

2.2 An Ecological Perspective

Rehabilitated ecosystems have characteristics that are more valued or valuable than those of thoroughly degraded ecosystems. Reconstructed images of ecosystems as they were just before European settlement can help one anticipate what ecosystem rehabilitation strategies might achieve. Although a thorough restoration of ecosystems to pre-European times is neither feasible nor in all probability desirable, rehabilitation can be viewed as a quite acceptable compromise between restoration, mitigation, and enhancement (Francis et el. 1979).

2.2.1 The Land-Stream-Bay-Lake Continuum

It is helpful to consider the Long Point ecosystem from the perspective of the hydrological relationships that constitute the land-stream-bay-lake continuum. Consider the Long Point ecosystem and the area of immediate influence. Include the upland drainage origins, the smallest feeder streams near the upper boundaries of the drainage basin, all the lower coalescing tributaries and their catchments that may encompass ponds and wetlands, the deltaic marshes, and bay and lake parts of the system. This ecosystem has considerable self-regulatory capabilities that determine in part how the system responds to stresses of natural and cultural origin and how the system recovers from the effects of such stresses if given an opportunity to do so. The text of this section is, in broad outline, generally consistent with the works of Woodwell (1970), Regier and Henderson (1973), Margalef (1975), Kitchell et al. (1977), Karr and Schlosser (1978), Vannote et al. (1980), Rapport et al. (198 1), and Karr and Dudley (1981).

Several centuries ago all but a few bluffs of the terrestrial parts of the Long Point ecosystem were strongly vegetated. The terrestrial area was mostly covered by forests, but there were some meadows near streams and extensive marshes and wetlands at the lake shore and at the base of Long Point. The main ecological associations that constitute this continuum are as follows:

(1) Tableland areas with small-sized streams. The natural vegetation reflects the extensive area of well-drained soils and moderating influence of the lower Great Lakes. On the widespread lighter soils, white pine, white, red, and black oak predominated naturally (Jackson 1958). Also common were loamy soils, typically climaxed by beech and sugar maple and accompanied by basswood, yellow birch, and white ash. Poplar, pin and black cherry, white birch, and shagbark hickory were residual or pioneer species following fire or cutting (Jackson 1958). Precipitation or melting snows would have drained rapidly into narrow valley lands, often containing small swamps around streams where yellow birch, white cedar, black ash, white elm, red and silver maple, and willow were abundant (Jackson 1958). These uplands and valley lands supported marten, fisher, lynx (Maya11 1958), white-tailed deer, turkey, black bear, passenger pigeon (Barrett 1977), and other animals requiring relatively large tracts of unspoiled forest land.

Streams flowing through these well-vegetated environments would have had stable banks. Most of the tributaries of the Long Point ecosystem were heavily shaded so that little photosynthesis and plant growth occurred directly within them. Leaves, twigs, terrestrial insects, and animal wastes (the “natural pollution”) were the raw materials for the food web for the aquatic animals of this system. Such a food web begins with the decomposition of organic litter by bacteria and fungi, the shredding of the litter by aquatic stages of insects and other invertebrates, and the ingestion and digestion of such partly decomposed material. Sculpins and brook trout thrive on such detritivores.

(2) Upland areas heavily incised by valley lands containing moderate-sized streams. The main difference between the terrestrial conditions in this type of environment compared with those in (1) was the much larger area of loamy soil and associated vegetation. The valley lands afforded protection to Carolinian species at the northern periphery of the range, such as tulip tree, pignut hickory, pin and chinquapin oaks, black gum, blue ash, magnolia, pawpaw, Kentucky coffee tree, red mulberry, and sassafras (Jackson 1958). Shrub and wetland environments supported cottontail, beaver, raccoon, weasel, ruffed grouse, woodcock, belted kingfisher, catbird, a variety of warblers, and other associated animals.

Streams in these environments were of sufficient width that they could not be fully shaded. One consequence was an increase in aquatic plants in streams. These may have been almost microscopic in size, such as algae that anchor themselves to stones, roots, or relatively firm bottom material. Filamentous algae may have occurred sparsely. With in-stream photosynthesis, the overall food web starts with the green plants, which are then grazed on by specialized insects and snails whose wastes pass through decomposing bacteria and fungi to detritivores such as clams and suckers. The nearshore parts of such streams were dominated by streamside vegetation. Crayfish, darters, and dace fed on grazing and shredding insects and were preyed upon by brook trout and creek chub.

(3) Flood plains and deltas in lowlands with larger-sized rivers. These environments were permanently, seasonally, or periodically flooded. Flooding was a direct consequence of topography and volume and timing of fluvial runoff. Wetland vegetation predominated, woody vegetation in particular. Black willow, red osier dogwood, speckled alder, silver and red maple, white elm, swamp white oak, black ash, white cedar, swamp loosestrife, reed canary grass, bluejoint grass, cattail, and sedges all occupied these carrs, swamps, and marshes. Moose, otter, beaver, snowshoe hare, mink, muskrat, weasel, great blue heron, blue-winged teal, wood duck, least and American bittern, green heron, flycatchers, swallows, redwinged blackbird, and other creatures utilized the lowland environments.

In the broad meandering streams of lowlands, terrestrial and aquatic vegetation intergraded with submergents. Thick beds of tape grass, waterweed, and milfoil photosynthesized to produce raw material for grazers and shredders, and other organisms. They also provided surfaces for attachment of very complex microassociations of small organisms. Much of the organic and chemical material that washes into such areas tends to be strained out, at least temporarily. Fall storms in the bays and lake and spring freshets in the streams may annually have scoured out much of the vegetation in such areas, dictating that annuals rather than perennials be dominant in them. Shiners, largemouth bass, and northern pike thrived in such associations.

Where the continuum, from (1) through (3) above, was curtailed by internal drainage, pond bogs resulted. Wetland vegetation accumulated and water became acidic. Tamarack, *Sphagnum* mosses, sedges, and black spruce predominated. These environments were relatively impoverished of wildlife. Bogs were common in the drainage basin of Long Point Bay in the early 1800's, and in fact constituted the main source of iron for Upper Canada's first ironworks at Normandale (Blake 1963).

(4) Shore zone environments in Lake Erie. Along the shore out of the immediate influence of rivers, two basic types of condition existed. In unprotected locations an association broadly similar to that of open streams may have developed (Hynes 1970), though the very same species may not have dominated in both conditions. Little vegetation could survive because of unstable substrate. Spottail shiner, johnny darter, and a few other species of fish occurred, but in relatively sparse populations.

In protected locations, extensive marshes developed. These productive environments abounded with cattails, burreeds, bullrushes, sedges, water lilies, pondweeds, milfoils, and many other plants. Much of the vegetation, including dead vegetation, stayed in place from year to year because waves and currents were insufficiently strong to break it up and wash it away. Thus these areas had bottoms of soft, decomposing organic material. They, too, intercepted and anchored dissolved materials, as well as flotsam and jetsam carried into them by downstream or longshore currents, then held them in place sometimes for many years. Sunfish, smallmouth bass, bullheads, turtles, muskrat, marsh wrens, mallards, Canada geese, and other biota were abundant.

(5) Offshore waters of moderate depth. Here sunlight was attentuated enough that it was insufficiently strong to permit photosynthesis at the bottom. But the waters were not sufficiently deep for summer stratification into two layers, i.e., with a warm surface epilimnion and a cold bottom hypolimnion. Floating plankton of both land and animal types thrived in the upper parts of the water column, and on the bottom existed a kind of decomposer association that resembled in some ways the decomposer associations in the small shaded tributaries and shaded edges of the larger tributaries. Emerald shiner, yellow perch, walleye, channel catfish, and sturgeon occurred here.

(6) Deeper offshore waters. We bounded the Long Point ecosystem on the lake sides so as to exclude a sixth kind of association, to a large extent. This association, really a two-tiered association in summer, occurred in water deeper than about 10 m. The warm epilimnion's association resembled the pelagic part of the unstratified association of moderate depth. But the cold hypolimnion's association was quite different and was dominated by large predacious plankton and such cold-water fish as lake trout, lake whitefish, and burbot. These species move into the waters of moderate depth after the surface waters become suitably cold in fall and winter. Many spawned close to or in streams in late fall or winter.

In the Long Point ecosystem these six different types of local associations did not occur as sharply defined discrete cells in a mosaic, but were interrelated and intergraded in a dynamic, fluid continuum. The continuum related to the topography, substrate, climate, water medium, its dissolved substances, the organic syntheses that are elemental to life, and the time available for organic development.

What was the relative importance of each type of environment in the Long

Point ecosystem about 200 years ago? Almost the entire tributary system fell into the first two types, table and valley lands. These components are excluded for practical purposes from the Long Point ecosystem as we have defined it here. However, an important lesson of the continuum, as presented above, is that the conditions in the table and valley lands will affect those in the other four types of environment. Much of Inner Bay and the parts of Lake Erie included in our boundaries of the Long Point ecosystem fell into the fifth class, shallow bay, with seasonal invasions from part of the association of the sixth class of deeper lake. At the base of Long Point, and around the shores of the Inner and Outer Bay, were large areas of water dominated by the fourth type of submerged macrophyte beds and wetlands. The second type occurred to a limited degree with the fourth in the Long Point ecosystem: it occurs much more commonly in larger rivers. And the sixth type, deeper lake, was largely excluded because of how we defined the boundary of the Long Point ecosystem.

These types of associations each had distinctive processes for their own self-regulation. Organization for self-regulation tends to develop especially well in relatively stable, permanent, non-scoured substrates and structures such as flat table lands and valley lands of moderate slope that are well forested; overhanging vegetated banks with roots trailing in the water, wetlands, and stands and beds of perennial macrophytes; and gravelly and rocky rapids, bars, reefs, and moderately firm lake and river bottoms that are washed relatively clean occasionally by moderately strong currents and waves, but are not under constant physical stress.

In the primeval system of the Long Point region, such centers of self-organization were largely of the first two types, since the geomorphological features of the third type hardly occurred within the ecosystem boundaries.

Self-organization processes result in the creation of fairly complex associations, with numerous species that are relatively large and long-lived, at or near the centers of self-organization. The opposite is the situation at distances far removed from such centers. Larger organisms that thrive at centers of organization tend to dominate, exploit, and regulate smaller organisms that thrive at distances from such centers. Where sufficient centers occur, the aquatic ecosystem contains an abundance of large organisms of various kinds. Old sportsmen's tales of abundant trophy game and fish in primeval ecosystems are true in general.

At interfaces between air and land, air and water, or between water and land characterized by blowouts, violent waves, and currents (i.e., by processes of high kinetic energy) no ecological self-organization develops among the organisms. This would also be true in areas or interfaces of very low kinetic energy because the organisms would not be supplied by sufficient materials to support a complex association. Thus self-organization thrives in areas of moderate kinetic energy. Most of the primeval Long Point ecosystem fell within the moderate range of the spectrum; a stretch along the south shore of Long Point may be considered as high energy and bogs as areas of low energy.

One main inference from the analysis sketched above is that the larger organisms of the ecological association acted to stabilize an ecosystem that was built largely on sand. It might be expected that destruction of the larger organisms would act to impair the degree of self-organization in favor of the smaller types of organisms with little self-regulatory capability. Also, disturbance of centers of organization would adversely affect the large organisms dependent on them to the consequent advantage of the smaller organisms. Humans generally favor the larger organisms whether of aquatic or terrestrial milieu, or whether plants or animals.

2.2.2 The Stress-Response Ecological Paradigm

A variety of conceptual approaches exist for interpreting the organization and functioning of ecosystems. Regier (1980) has, for example, identified six different approaches to ecological analyses (Table 2.1).

The stress-response ecological paradigm was the one we adopted for our earlier study (Francis et al. 1979) and subsequently for this prospectus. Its main conceptual advantage is that analyses of the stresses degrading an ecosystem can often be linked directly to management measures that could alleviate or remove stresses, and in so doing, release some of the natural recovery processes that constitute the resilience of ecosystems. We use the term stress with respect to natural and cultural events and processes in the sense of a forcing process, a perturbing influence, a stimulus that alters the existing association at least temporarily, the appearance from outside the ecosystem of a somewhat unusual phenomenon, and an activity or intervention with respect to the structure or process of an ecosystem. The immediate effects on the system of a stress may be viewed as an impact, a wound, or a degradation of its characteristics (Rapport et al. 1981).

If a stress acts temporarily or in a transient manner and then abates, a recovery succession usually occurs that gradually obliterates the primary impact or heals the wound. If a stress once initiated is maintained persistently or permanently at a fixed level, then an adaptive response usually occurs that modifies the primary impact but in a different direction from that which would restore the original association. The persistent stress then becomes a normal

Table 2.1 A classification for different approaches to ecology. Internal and external correspond approximately to reductionist and holist. Conceptual is what captivates truth-seeking academic theoreticians and practical is what field-oriented workers actually use (from Regier 1980).

Perspective	Conceptual	Practical
External	Phenomenology, as in study of our perception of nature	Stress-response, as in renewable resource management
Internal	Resource allocation, as in study of optimal foraging	Compartment-flow, as in intensive culture of fish, or grasslands
Synthesis	General systems theory, as in study of interactive hierarchic systems, deductively or inductively	Applied systems analysis, as in eclectic simulation for adaptive management, or using adversarial techniques as in litigation

feature in the new association. If the new association has undesirable features, it may be said to be degraded. Whenever a stress keeps building through time and/or space, the primary impact will likely intensify cumulatively; the system will be in the process of degrading progressively.

So far, reference is made to the "distress" connotation of the term "stress." Distresses act to the disadvantage of the large, long-lived, endemic organisms typical of the natural climax association and act to impair self-regulatory processes. "Eustresses" act in the converse manner (see Rapport et al. 1981).

In the short term (within a period of several years) water-level fluctuations cause the death of some organisms of a wetland and provide habitat for the invasion of new areas by those species. In the longer term (say within a period of two decades) the fluctuations are responsible for the lateral extent of the wetlands. Provided that the fluctuations occur around some long-term mean water level, the larger the amplitude the greater the real extent of wetlands. So a natural distress in the short term with bad effects for some individual organisms is also a natural eustress with good effects for the whole association in the longer term. It should be understood that this example is simplified a bit since other factors are also involved in determining the area of a wetland.

Almost by definition, the natural stresses sketched in Section 2.1 must be seen as eustresses, in the long term, because the very existence of the wetland association depends on them. They are here termed distresses in the short term, as they affect individual species and small locales. Direct human interventions in degraded parts of the system, with restorative, mitigative, and rehabilitative practice, might be termed eustressful.

Use of the terms may therefore be summarized as follows:

Transient distress	→	Immediate impact	→	Subsequent recovery succession toward original climax. In the long term this may foster a healthy state of original climax.
Transient eustress	→	Immediate impact	→	Subsequent enhanced succession toward original climax
Permanent distress	→	Immediate impact	→	Subsequent adaptation toward a degraded form of sub-climax
Permanent eustress	→	Immediate impact	→	Fosters succession toward an enhanced form of climax

Seemingly very different stresses may have somewhat similar immediate impacts, followed by similar recovery or adaptive sequences. Thus a non-persistent herbicide and a violent storm may both lead to the die-off of wetland vegetation to be followed by a recovery succession toward the original association.

Sometimes, perhaps often, a stress will have a direct impact to be followed by one or more indirect impacts as a result of a ramification of effects through ecosystemic connections. An herbicide application may result in the death of vegetation; residuals of the herbicide may be accumulated by bottom organisms and transferred to fish and eventually to humans. Depending on how unselective the toxic material of the herbicide, it may have adverse effects on one or more of the organisms in the food web which is permeated by the herbicide. In some instances it may conceivably have beneficial effects. The challenge for sustainable resource management is to use nature in less distressful ways and to cooperate with nature in new eustressful ways. It is a challenging but not a daunting prospect.

2.2.3 A Stress-Response Analysis of the Long Point Ecosystem

The Long Point ecosystem as portrayed is a complex, evolving system of natural and cultural features and processes. It is sensitive and resilient. The sensitivity relates to the unique and ephemeral components that are typified by the dune and inter-dune environments. Its resilience relates to recovery after a perturbation and can be attributed to the survival of a core of the natural ecosystem, particularly the extensive perturbation-dependent or tolerant marshes, and a diversity of refuges for biota.

Just as important, however, has been the fortuitous preservation of essential inputs to the system and limitation of degradative stress. Given slightly different economic circumstances, ownership patterns, or other historic events, the stress regime in the Long Point ecosystem could have been vastly different, and the ecosystem might have transformed radically.

Some transformation has occurred. As a means of preventing larger scale transformation in the future, it is necessary to develop an ecologically sensitive and comprehensive understanding of the Long Point ecosystem. Sections 2.1 and 2.2 summarized the general understanding that has been obtained about this ecosystem, such that it is possible to discuss the key ecological features and flows and the manifestations of various stresses.

A workshop, convened in 1978 under the auspices of the previous study on Great Lakes Ecosystem Rehabilitation, developed a listing and classification of stresses. They can be grouped into major categories approximately as shown in Table 2.2. With this information as background (Francis et al. 1979), the Great Lakes Ecosystem Rehabilitation Working Group convened a Long Point workshop in March 1980 at which a listing of stresses was developed (Regier et al. 1980). The Long Point workshop specified directly some of the more generic stresses that were identified for the Great Lakes as a whole, omitted some of the other stresses that were relatively unimportant at Long Point, and added some stresses that related more specifically to the terrestrial parts of the Long Point ecosystem. The list with examples is as follows:

Fishing and other harvesting of biota:
- commercial, sport, and domestic fishing
- hunting and trapping

Table 2.2 A taxonomy of stresses that affect aquatic ecosystems of the Great Lakes

Natural background processes	Battering storms; rains and floods; water level cycles; spells of hot or cold weather; forest and marsh fires; disease outbreaks
Harvesting of renewable resources	Fishing whether commercial, angler, or by party boat; hunting for ungulates, upland birds, or waterfowl; trapping for **muskrat** or fox; withdrawal of water for consumption
Loading by substances and heat energy	Inert solids and suspensions of sand and clay; nutrient materials that fertilize plants and plankton; poisons that kill organisms; contaminants that affect health of organisms; heat that raises the temperature of the water
Restructuring the morphometric form of water bodies	Filling in deeper parts with sediments; damming streams; modifying the shoreline by bulkheading, infilling, etc.; dredging to deepen parts of the basin; stirring up bottom by boating and shipping
Introduction of non-native organisms	Intentional stocking of preferred organisms which may nevertheless becomes pests; accidental invasion via canals; accidental introduction via bilge water, private aquaria, anglers' bait buckets, etc.

Recreational camping, hiking, swimming, birdwatching:
- Long Point and Turkey Point Provincial Parks, Long Point Bird Observatory, and other sites

Nutrient loading, fertilizer runoff, eutrophication:
- Port Rowan sewage
- farm fertilizer runoffs

Sediment loading:
- Norfolk sand plain erosion
- creek valley erosion

Modification of streams and natural channels:
- Delhi dam
- marsh channelization

Introductions and invasions of exotic species, mostly fish:
- lamprey, goldfish, carp, Pacific salmon, alewife, smelt, Eurasian milfoil

"Development," such as cottages and residences, commercial premises, roads, bridges:
- Long Point town, Turkey Point, Port Rowan, marinas, causeway

Dyking and draining of wetlands and marshes:
- Turkey Point Marsh and Big Creek Marsh (dyking proposed)

Loadings of microcontaminants and toxic materials:
- DDT, PCB, mercury

Filling low-lying areas, bulkheading shorelines, placing groynes on beaches, etc.:
- Highway No. 59, boatslips between Port Rowan and Long Point beach

Dredging of shipping or boating channels, mining, or extraction of sand:
- Channel to Port Rowan, boatslips between Port Rowan and Long Point

Disturbances of wildlife equilibria not subjected to management:
- white-tailed deer on Long Point

Air pollution, long-range, perhaps mostly from the south:
- coal- and oil-fired energy and industrial production

Degradation by major incidents, oil spills, tanker accidents:
- possibilities associated with Nanticoke complex and shipping

Loadings of organics with high biochemical oxygen demand:
- organic sewage, livestock pollution in creeks

Burning of the marshes and on the peninsula:
- marsh management, natural fires

Shipping, stirring up sediments, boat wake on shore:
- occurs throughout most of Inner Bay

Thermal loading:
- Nanticoke thermal generating station

Entrainment and impingement of biota:
- intake pipes and screens

Vegetation control:
- herbicide and mechanical for boating, fishing, appearance, and agriculture

Water level control:
- international shipping, shore property protection

Ice control:
- winter navigation, thermal effluent

Weather modification:
- global carbon dioxide, atmospheric particulates

Deposition of flotsam and jetsam:
- plastic jugs, old lumber

Effects of lights on birds and insects:
• lighthouse, settlements

A description of the kinds of evidence or manifestations of most of these stresses is summarized in Francis et al. (1979) and more detailed information on the effects can be found in the work of Regier (1979), Bradstreet (1977), Hamley (1981), Knight (1983), and Whillans (1985). These more detailed analyses of stresses help provide easy entry to the more practical issues of rehabilitating degraded features.

Secondary factors or transport mechanisms also need to be considered in developing a rehabilitation scheme. For example, a fertilizer runoff problem cannot properly be considered from a rehabilitation perspective without information on influences such as surface runoff, river dynamics, and nearshore currents. Altering a transport mechanism or problem-intensifying condition may be sufficient to curtail a stress or suppress it until a basic correction is organized. Table 2.3 lists some of these secondary factors or transport mechanisms that might form the foci for complementary or preliminary rehabilitation activities.

When stresses act on an ecosystem, some may have similar effects, as already indicated. But they sometimes act synergistically, in ways that magnify their effects beyond what would be expected if one could just sum the effects that occur when each acts in isolation (Regier et al. 1980). Sometimes they may act antagonistically, with the result that one stress serves to reduce the impacts of other stresses.

The following somewhat grand generalization was drawn from a comparative study of many aquatic ecosystems (Paloheimo and Regier 1982), and is broadly applicable to the Long Point ecosystem.

- The major stresses, or effects of human uses, often act synergistically so as to exacerbate each other's adverse effects. They seldom act antagonistically so as to cancel out adverse effects.
- The stresses alter the fish association from one that is dominated by large fish usually associated with larger streams, with the lake bottom and lake edge to one characterized by small mid-water species. A similar change happens with respect to vegetation: firm rooted aquatic plants near shore originally are replaced by dense suspensions of open-water plankton algae or filamentous algae in shallow areas. In addition, the association of relatively large invertebrates such as mussels and crayfish living directly on bottom substrates is supplanted by an association characterized by small burrowing insects and worms such as midge larvae and sludge worms.
- With the above changes comes an increased variability from year to year in abundance of particular species, and in particular in landings of different fish species by anglers and commercial fishermen.
- The shift from large organisms associated with the bottom to small organisms in the bottom and in mid-water is not accompanied by a great increase in the total biomass of living material, at least not of the marketable species.
- Market and sport value per unit biomass is generally much lower with small mid-water fish species than with large bottom species, and processing costs are higher. Similarly, the aesthetic value of the rooted plants near shore with

Table 2.3 Primary stresses and examples of factors which mitigate or enhance the magnitude of effects of primary stresses in the Long Point ecosystem (from Regier et al. 1980).

Primary stresses	Factors affecting magnitude of stress	Factors affecting effects of stress
Fishing and other harvesting of biota	cost of harvesting, access, biologic capital	level of put-and-take management, sanctuaries
Recreational camping, hiking, swimming, birdwatching	access, cost, alternative sites	refuge areas
Nutrient loading, fertilizer runoff, eutrophication	land use, runoff, river dynamics, soil types	wetland buffer, trophic condition, nearshore currents
Sediment loading	stream-side buffers, river dynamics, exposure	nearshore currents, nature of sediment sinks
Modification of streams and natural channels	configuration of modification, timing of modification	fishways, alternative routes
Invasion and introduction of exotic species, mostly fish	immigration routes, fish culture practices	subsidization of naturally occurring species
“Development” such as cottages and residences, commercial premises, roads, bridges	zoning, services, natural hazard risk	buffer zones, island biogeography
Dyking and drainage of wetlands and marshes	alternative technology, use, predictive capability	storms, successional state
Microcontaminant and toxin loading	fail-safe technology, legal disincentives, regulation	warning, sedimentation, biologic turnover rate, food preparation
Filling low-lying areas, bulkheading shorelines, placing groynes on beaches, etc.	education, construction techniques	seiches, storms, wave action
Dredging of shipping or boating channels, mining, or extraction of sand	marina location, technique	density of aquatic vegetation, currents
Management of wildlife disequilibria	predictive capability, demand for target species, “experimental management”	subsidization of forage base, species balance
Air pollution, long-range perhaps mostly from the south	monitoring and control capability	climatic trends, biotic sensitivity
Degradation from major incidents, oil spills, tanker incidents	emergency planning, location of incidents in relation to key ecosystem components	resilience of biota
Input of organics with high biochemical oxygen demand	timing, distribution of inputs	nearshore currents and circulation, natural biochemical oxygen demand

Table 2.3 Continued

Primary stresses	Factors affecting magnitude of stress	Factors affecting effects of stress
Burning of marshes and vegetation on the peninsula	time elapsed since last fire, season	climate, natural fire dependency
Shipping and stirring up sediments, **boat wake** on shore	water depth, season of activity	natural wave action, vegetational buffer
Thermal loading	season, consistency of loading	fauna1 mobility, fauna1 thermal preferences
Entrainment and impingement of biota	season, intake loaction, intake water velocity	fauna1 mobility, bottom topography
Vegetation control	cost, persistence of herbicides if used	water level regime
Water level control	timing, direction of water level charge	climatic variation, seiches
Ice control	cost. demand	shore ice sensitivity, location of biotic winter areas
Weather modification	predictability	natural climatic cycles
Water diversions	cost, engineering alternatives	natural water level regime
Release of flotsam and **jetsam**	education	currents, winds
Lighting of nocturnal habitats of birds and insects	seasonality of operation	weather, fauna1 migration patterns

the associated animals is higher than a pea-soup-like mixture of suspended algae or swaths of decaying filamentous algae.

The effect on fisheries is that labor-intensive specialized fisheries (sport and commercial) tend to disappear, though highly mechanized, capital-intensive enterprises may persist if the combined stresses do not become excessive and if the fish are not so contaminated as to become a health threat for those who would eat them. Beyond that, people generally find such degraded systems offensive and quite literally turn their backs to them.

With an appropriate change of terms, the above list could be generalized to apply as well to the wetland and upland parts of the Great Lakes ecosystem. The overall generalization is a description of an ecosystemic impact and response syndrome to most human uses as they have been conventionally practiced in the Long Point ecosystem (see also Rapport et al. 1985). The features of this syndrome help to explain why there is usually so much confusion about which user group or set of human activities was responsible for a particular adverse effect on the ecosystem, especially where the different stresses have not been carefully monitored. Often more than one group of users or activities are responsible jointly and synergistically. This reveals the shortcomings of management approaches that deal with different user groups or resource management practices, as though their involvements with the ecosystem were entirely independent of each other.

Relatively little of the Long Point ecosystem is as yet severely degraded. Some rehabilitation of degraded features has already occurred in the Long Point ecosystem and its watershed. On the mainland some large areas of blowing sand have been stabilized through reforestation. On Long Point itself the terrestrial ecosystem is gradually recovering from forest cutting which ended several decades ago. The waters of the Central Basin of Lake Erie that wash along the south shore of Long Point are now not as enriched as they were a decade ago, thanks to the binational program of phosphate control carried out under the 1972 and 1978 Water Quality Agreements (International Joint Commission [IJC] Great Lakes Water Quality Board 1983). If efforts undertaken in 1983 prove successful, the bald eagle may soon nest again in Long Point and patrol the beaches scavenging dead fish (Hockman 1983).

During the past decade there have been many studies of rehabilitation and restoration of degraded lakes and rivers in the United States, in many European countries, and in Canada. They have shown that many forms of degradation can be corrected to the great benefit of the sensitive uses of these ecosystems. But the recovery process is often gradual and lengthy and involves changes in the patterns of use that are difficult to impose on strong vested interests.

2.3 A Conceptual Ecological Model for the Long Point Ecosystem

2.3.1 Model Development

Any one of a variety of conceptual approaches could be used to comprehend and model an ecosystem (see Table 2.1). No single approach is necessarily the best and each can provide a particular perspective on an ecosystem. The stress-response approach is the predominant one in contemporary management-oriented ecology; in this section the "external practical" approach is combined with an "internal practical" to produce a form of "applied systems analyses."

Knight (1983) developed a conceptual ecological modelling framework for understanding the complex and interdependent relationships of the Long Point ecosystem. The research framework is based on a modelling procedure developed by Odum (1971) who used symbols in system diagrams to illustrate, in a graphical format, the major components and interactions of an ecosystem. Knight (1983) utilized this approach to organize and integrate the ecological components and processes described in previous sections and illustrated them in a systems format. Figure 2.3 illustrates the components used to model the Long Point ecosystem.

The aim of conceptual modelling is to characterize the various resources (biotic communities) of the Long Point ecosystem interacting with energy sources and storages, biophysical processes, food chain relationships, and cultural stresses. These variables were examined in two interrelated levels of analysis: (1) modelling the entire Long Point ecosystem and (2) modelling one community

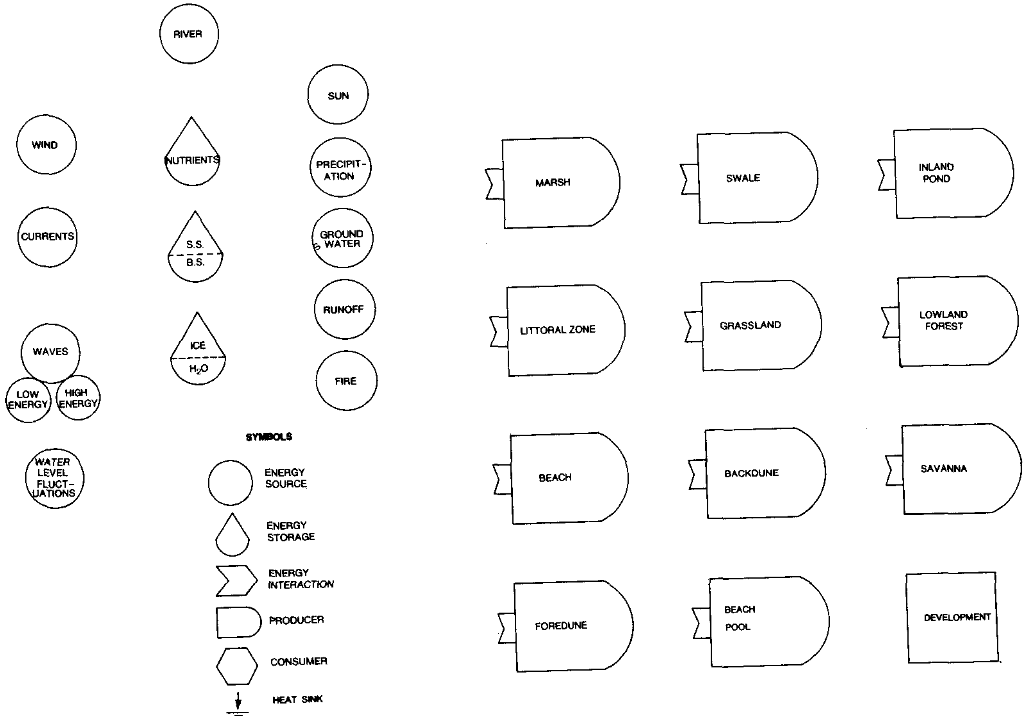

Figure 2.3 Regional model components of the Long Point ecosystem (from Knight 1983)

(Grassy Marsh). Each level of hierarchical modelling represents a distinct yet interrelated focus. The description of the model in the next section is taken directly from Knight (1983).

2.3.2 Conceptual Model of the Long Point Ecosystem

An ecosystem model of the Long Point. region characterized by the interaction of biotic communities with offshore energy sources and storages, biophysical processes, and water interactions is shown in Fig. 2.4. Based on existing vegetation and landform classifications of Long Point, Knight (1983) divided the area into 20 distinct biotic communities. Table 2.4 identifies these and briefly characterizes the dominant biotic associated with each.

The community components as illustrated in Figure 2.3 have been divided into distinct units based on the dominant successional stages of vegetation. For example, the marsh community is shown as Dense Grassy Marsh, Grassy Marsh, and Cattail Marsh. Similarly, Savannah has been divided into Cottonwood Savannah and Oak-Pine Savannah. Upland forest is represented by Pine-Cedar Upland Forest and Oak-Maple Upland Forest. Lowland forest is depicted as Wet Woodland and Slough communities. The model represents the present-day natural system which has been altered by man and this is reflected in the model. For example, the Plantation community and the Cultivated Upland have been influenced by cultural development.

The various forms of cultural development influencing the area are depicted as being in situ within the community they affect. Thus the provincial park development affects some of the Beach, Swale, Plantation, Foredune, and Back Dune communities. Similarly, each affects marina development affects the Littoral Zone and Cattail Marsh communities.

Long Point is influenced by the external energy sources of winds, currents, energy waves, and water levels (offshore processes). These energy sources interact in the offshore environment with suspended and bottom sediment, ice or water, and nutrients to create characteristic patterns of water flow. The direction of water flow is illustrated by solid lines and arrows. Water flow is a function of the local hydrological regime which comprises the energy sources of precipitation, evaporation, runoff, groundwater flow, and offshore coastal processes. Precipitation and evaporation are shown in the model as inputs and outputs, respectively, in the Cultivated Upland although they influence all the communities.

Water flow from the Cultivated Upland is transported directly by overland flow into the Wet Woodland, Big Creek, and the Dense Grassy and Grassy Marsh communities. Big Creek also drains directly into the Dense Grassy Marsh and Grassy Marsh. All overland and river flows are unidirectional.

With respect to offshore water interactions, there exist bidirectional flows of water among communities. They include offshore waters and Littoral Zone, Littoral Zone and Beach, Littoral Zone and Beach Pool, Beach Pool and Beach, and finally Cattail Marsh and Littoral Zone (east). Feedback can also be traced among communities. For example, there exists a closed feedback loop from the Littoral Zone to Beach to Beach Pool and back to the Littoral Zone (west).

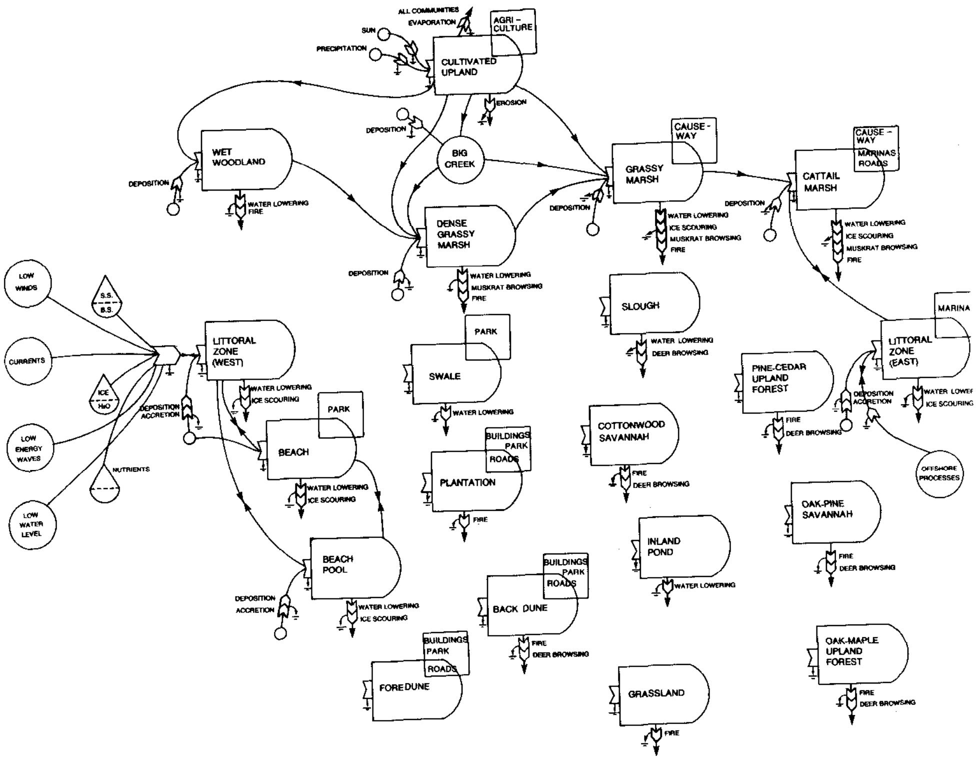

Figure 2.4 Conceptual model of the Long Point ecosystem (from Knight 1983)

Table 2.4 Twenty biotic communities in the Long Point ecosystem. Some of the characteristics or unique plants and animals are indicated for each community based on data extracted from Bradstreet (1977); Catling and Reznicek (1981); Cruise (1969); Hefferman and Ralph (1978); McCracken et al. (1981); Whillans (1979).

Name of biotic community	Plants and animals
Predune	dune grass, switch grass, bluestem beardgrass, sea rocket, Fowler's toad, eastern hognose snake, prairie deer mouse, spotted sandpiper
Backdune	sand dropseed, little bluestem, milkweed, worm wood, beach pea, scouring rush, yellow puccoon, fox snake, kingbird, killdeer, monarch butterfly
Oak-maple upland forest	red oak, white oak, chinquapin oak, white ash, hop-hornbeam, red maple, sassafrass, black cherry, basswood, sugar maple, white pine, white-tailed deer, eastern chipmunk, woodcock, eastern wood pewee, flicker, red-headed woodpecker, warbling vireo, American redstart
Cultivated upland	annual bluegrass, love grass, rye grass, bent grass, timothy, crab grass, barnyard grass, woodchuck, ringnecked pheasant, brown-headed cowbird
Wet woodland	silver maple, red maple, swamp white-oak, black ash, buttonbush, speckled alder, dogwood, rice cutgrass, muskrat, great blue heron, wood duck, hairy woodpecker, mourning dove, prothonotary warbler
Grassy marsh	sedges, loosestrife, rushes, reed grass, arrowhead, lake chubsucker, bowfn, least bittern, Virginia rail
Dense grassy marsh	sedges, bluejoint grass, arrowhead, water plantain, pickerel weed, meadow vole, mink, blue-winged teal, swamp sparrow, spotted turtle
Cattail marsh	cattail, bulrushes, reed canary grass, wild rice, spike rush, white and yellow lilies, coontail, pondweed, muskrats, pumpkinseed, bluegill, black crappie, bullfrog, leopard frog, green frog, chorus frog, map turtle, snapping turtle, painted turtle, Forster's tern, common gallinule, least bittern, long-billed marsh wren, red-winged blackbird
Littoral zone west	filamentous green algae, white bass, channel catfish, gizzard shad
Swale	rushes, umbrella sedges, three-square bulrush, bur-marigold, gentain, grass of parnassus, sneezeweed, yellow flax, bladderwort, lake chubsucker, carp, American bittern, spotted turtle
Beach pools	filamentous green algae, alewife, johnny darter, lake chubsucker, blackchin shiner, bluntnose minnow, soft shell turtle, common tern
Beach	sanderling, ringbilled gull
Slough	tamarack, white cedar, white birch, white pine, bluejoint grass, sedges, marsh fern, buttonbush, loosestrife, spring peeper, leopard frog, long-tailed weasel, kingbird, yellow warbler

Table 2.4 Continued

Name of biotic community	Plants and animals
Plantation	white pine, rye, wheat, barley, cabbage, tomatoes
Cottonwood savanna	red cedar, eastern cottonwood, ground juniper, switch grass, little bluestem, indiangrass, eastern cottontail, white-tailed deer, brown thrasher, grackles, chipping sparrow, song sparrow
Pine-Cedar Upland Forest	white pine, white cedar, red oak, white birch, red ash, striped skunk, woodcock, whip-poor-will, brown snake
Littoral zone east	pondweeds, coontail, tape grass, waterweed, bladderwort, stonewort, hornwort, milfoil, smallmouth bass, walleye, sheepshead, yellow perch, brown bulhead
Inland pond	water willow, tamarack, bluejoint grass, marsh fern, sedges, buttonbush, central mud minnow, white sucker, red-winged blackbird, painted turtle, Blanding's turtle, spring peeper, bullfrog, green heron, wood duck, common yellowthroat
Oak-pine savanna	white pine, red oak, white birch, Kentucky bluegrass, Canada bluegrass, eastern cottontail, white-tailed deer, red fox, bald eagle, great homed owl, yellow-billed cuckoo, great crested flycatcher
Grassland	red oak, sugar maple, Canada bluegrass, Kentucky bluegrass, melanic garter snake, white-footed mouse, eastern meadowlark, field sparrow

Feedback loops assure continued energy flows of water, sediments, nutrients, and organic matter needed to sustain the physical structure and biological life among these communities.

The model also illustrates ongoing physical processes associated with low energy conditions indicated as energy inputs and outputs. Inputs are considered as any external driving forces or materials added to a community and include low winds, currents, low energy waves, low water level, sun, precipitation, deposition, and accretion. Similarly, outputs indicate a loss of energy or materials from a community and include erosion, evaporation, water lowering, and ice scouring.

Deposition and accretion (inputs) are active processes influencing all the aquatic communities sustained by water interactions. In addition, within the aquatic communities, processes such as water lowering and ice scouring can be considered as outputs. Obviously these processes will have an effect on the physical and biological structure in communities.

Other output biophysical processes include erosion, fire, muskrat, and deer browsing that have influenced extensive portions of the entire Point, particularly in Back Dune, Cottonwood Savannah, Pine-Cedar Upland Forest, Oak Pine Savannah, and Oak-Maple Upland Forest communities. However, fire has influenced the most extensive portions of the Point.

Cultural stresses influencing the Long Point ecosystem are depicted in Fig.

2.5. Stresses are classified as inputs or outputs and organized in relation to the individual communities they influence. Each stress is numbered for convenience and referred to in the text.

Input stresses such as acid precipitation (1) and atmospheric particulates (2) are transported by prevailing winds and deposited throughout the ecosystems. Organic (3), nutrient (4), sediments (5), and micro-contaminant loadings (6) are transported and deposited in the Dense Grassy and Grassy Marshes by overland and river drainage from the Big Creek watershed. Other aquatic-related input stresses include spills (7), herbicide application related to weed control (8), boating (9), swimming (10), and introduced exotics such as carp, alewife, and Eurasian milfoil (11).

Output stresses are associated with the major structural development (12) such as roads, buildings, and marinas that are in situ within the community they affect. Other output stresses include coastal development such as dredging (13), dyking (14), bulkheading (15), groynes (16), and infilling (17). Additional output stresses include vegetation harvesting (18) of aquatic weeds and crops; recreational activities such as hiking (19) and wildlife viewing (20); various forms of harvesting including muskrat (21) and waterfowl (22) hunting; sport fishing (23); commercial fishing (24); and, at one time, logging (25). Deer browsing (26) is considered a cultural stress since man has eliminated predators of deer and restricted access by deer to the mainland. Similarly, man-induced fire is associated with recreational stresses (i.e., campsites) in the Provincial Park.

All input stresses are additive in that some external contingent elements are added to the system. These elements may take the form of pollutant loadings (microcontaminants) or exotic species (fish). Correspondingly, all output stresses can be considered as having a negative influence on the system by removing some element of the natural system. This could take the form of dredging (a removal of soil and plant life), or some form of harvesting (fishing, waterfowl hunting). In many instances stresses may, in fact, result in both additive and negative impacts. For example, fire can be considered as removing organic material but also may permit regrowth of species. Therefore it should be kept in mind that stress input/output classification is arbitrary and serves only as a convenient categorizer for modelling purposes.

The model indicates that the Dense Grassy Marsh, Grassy Marsh, and Cattail Marsh are all influenced by a variety of input and output stresses. All the marshes are influenced by pollutant loadings transported by overland runoff and river flow from the Big Creek drainage basin. Many forms of structural development, such as the causeway marinas, dredging, dyking, and infilling, occur throughout the marshes.

The Littoral Zone (east), which includes a large portion of Inner Bay, is affected by numerous input and output stresses. In fact, all 11 input stresses and 9 of 16 output stresses influence to some degree the structure and function of the littoral zone. This reflects, for example, water quality degradation associated with pollutant loadings for the Big Creek watershed, marina developments with associated dredging and bulkheading, and various forms of wildlife hunting.

Other communities influenced by structural development include Beach,

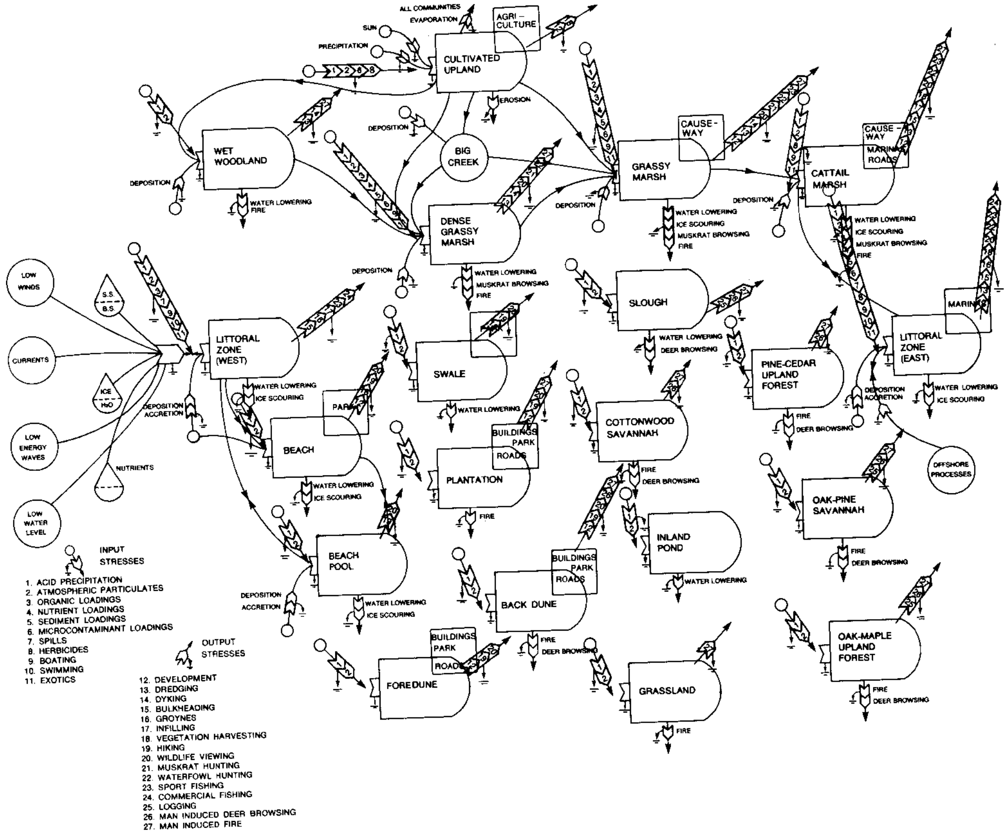

Figure 2.5 Culture Stresses acting on the Long Point ecosystem (from Knight 1983)

Foredune, Back Dune, Plantation, and Swale comprising the Long Point Provincial Park. Passive recreational activities such as hiking and wildlife viewing are also common stresses. Overgrazing by deer has significantly influenced vegetation in the Back Dune, Cottonwood Savannah, Slough, Pine-Cedar Upland Forest, Oak-Pine Savannah, and Oak-Maple Forest communities. Many inland communities continue to show signs of historic fires. They comprise the Back Dune, Grassland, Cottonwood Savannah, Slough, Pine-Cedar Forest, Oak-Pine Savannah, and Oak-Maple Upland Forest. Fire is also a significant stress in the wet Woodland and Marsh communities of Long Point.

2.3.3 Conceptual Model of a Grassy Marsh Community

Figure 2.6 illustrates a conceptual ecological model of a Grassy Marsh community. The internal components in the marsh represent the various producers, consumers, and elements in storage. Each component is numbered and referred to in Fig. 2.5.

The external energy sources, such as waves and currents depicted in the regional model, have been combined into one symbol-physical and offshore processes. Similarly, incoming nutrients, sediment, and water are also combined into one symbol to represent energy inputs. In this way, greater detail is permitted concerning the internal dynamics of the marsh.

The various flora and fauna known to inhabit the Grassy Marsh were organized into distinct components comprising similar species. Dominant (abundant) and rare or endangered adult species were listed in each component of the model from unpublished information in field studies conducted by CWS and from some published materials, e.g., Hardy (1979), McCracken et al. (1981), and Mudroch (1980).

Linkages between components represent generalized food chain flows of energy and material. Linkages in the model are shown as solid lines and arrows to indicate the direction of food and material pathways. For example, the sun provides radiant energy to the producers in the marsh to initiate the production of organic matter and subsequent food for higher order species (e.g., birds).

Unfortunately, information on food chain relationships is not available for this particular area (e.g., gut analysis). Therefore, information on the principal food and feeding habits of adult species in the marsh during spring and summer feeding conditions are based on data reported elsewhere, e.g., Butt (1957), Cochran and Coin (1970), Martin et al. (1951), and Scott (1954).

Marsh producers are divided into various emergent (3), floating (4), and submerged macrophytes (5) and the less conspicuous phytoplankton (2) and periphyton (1) populations. Consumers in the marsh comprise terrestrial and aquatic organisms such as the zooplankton (8), benthic invertebrates (16), insects (9), fish (7), amphibians (15), reptiles (14), birds (10), small mammals (12), and large mammals (13). Decomposers include bacteria and fungi (6). It should be pointed out that consumers such as birds and fish move daily or seasonally for food and shelter. Therefore, model boundaries are arbitrary but are useful for delineation of the system. Migrating waterfowl are considered external to the system because most species utilize the marsh only periodically as a staging area for migration.

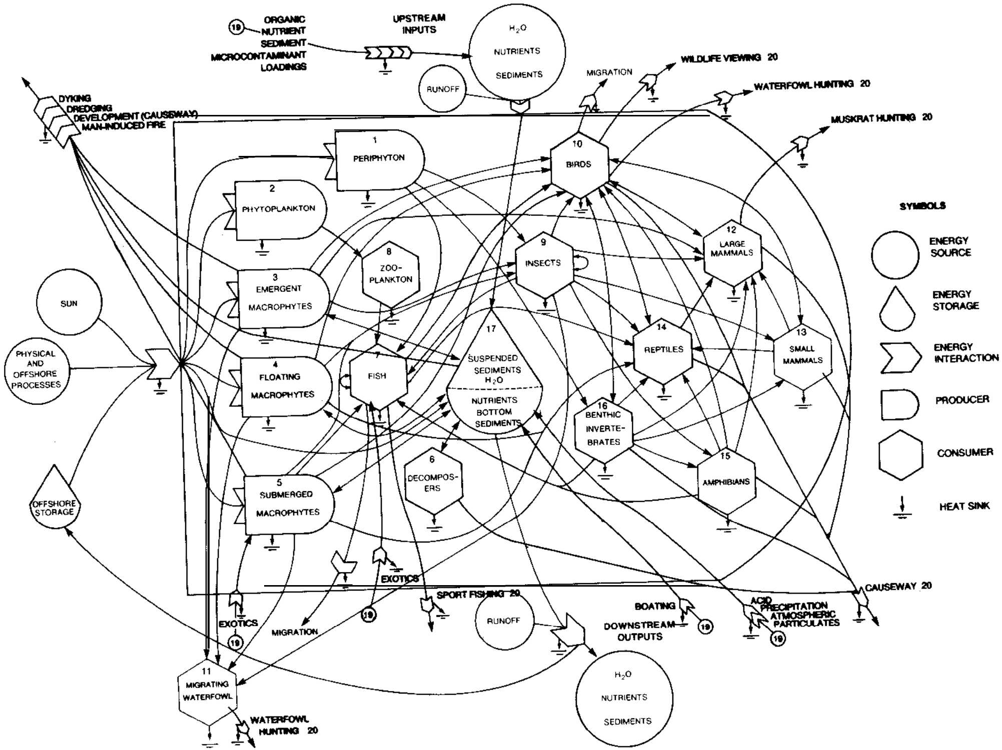

Figure 2.6 Conceptual model of a grassy marsh community-Long Point ecosystem (from Knight 1983)

Cultural stresses interacting with the various components in the marsh are also shown in Fig. 2.6. Cultural stresses are organized as inputs (i.e., microcontaminant loading) or outputs (waterfowl hunting) as they initially interact with the individual structural components of the system. The model suggests that different stresses affect different structural components of the marsh ecosystem,

Input stresses include organic, nutrient, sediment, and microcontaminant loadings associated with agricultural development from the Cultivated Upland transported by water to the storage in the sediments. Acid precipitation and atmospheric particulates are transported to the system by prevailing winds and deposited in the water and eventually in the sediments of the marsh. Exotic inputs include culturally introduced carp shown influencing the fish component and alewife and Eurasian Milfoil depicted in the submerged macrophyte component.

Output stresses are somewhat more varied and initially interact with many more components of the system. Recreational output stresses are, predominantly, hunting pressures on the birds and large mammals and fishing. Hunting pressures imply a loss of species, whereas wildlife viewing may interfere with nesting behavior. The major development in the marsh (the causeway) interacts with more of the model components than any other stress. The causeway would initially affect the storage of sediments and the hydrological regime in the marsh and the various macrophytes through habitat modification during the construction stage of development. The other animal components influenced by the causeway would be associated with road kills and loss of habitat. Other structural development such as dyking and dredging initially influence storage in the marsh and therefore the hydrological and sediment regimes may be altered. Dyking and dredging developments would also affect the macrophyte components through loss of habitat structure (vegetation) in the construction phase.

2.3.4 Higher Order Interactions

When modelling becomes overly cumbersome with many components and interactions, interaction matrices provide a systematic framework for examining in an ordinal sense the binary relationships among components (Roberts 1978).

Interaction matrices are used to formulate 1st, 2nd, 3rd order . . . (kth order) food chain interdependencies in the marsh. Table 2.5 shows the first order food chain relationships among the components of the marsh as depicted in the model. Each component is considered as a separate entity and is individually numbered in the matrix. Numbers in the column denote the presence or absence of food chain relationships from one component to another. For example, a food chain from emergent macrophytes (3) to insects (9); exists, therefore, a 1 exists in the matrix.

The matrix indicates that insects provide a direct food source to eight other components in the marsh. Insects are an integral part of the food chain in the marsh by providing food for fish, other insects, birds, migrating waterfowl, large and small mammals, reptiles, and amphibians. In addition, the various macrophytes are important sources of food to insects, birds, migrating waterfowl, large mammals, and reptiles. Furthermore, bi-directional links exist among the

Table 2.5 First order food chain relationships in grassy marsh community (from Knight 1983).

From	To 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Periphyton	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0
2 Phytoplankton	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3 Emergent Macrophytes	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1
4 Floating Macrophytes	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	1
5 Submerged Macrophytes	0	0	0	0	0	0	1	0	1	1	1	0	0	1	0	0	1
6 Decomposers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7 Fish	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
8 Zooplankton	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9 Insects	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0
10 Birds	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0
11 Migrating Waterfowl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 Large Mammals	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
13 Small Mammals	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0
14 Reptiles	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
15 Amphibians	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0
16 Benthic Invertebrates	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0
17 Storage	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	1	1	1	7	1	5	10	4	7	3	8	2	2	4

various macrophytes and storage in the marsh. This represents the accumulation and breakdown of organic matter and subsequent nutrient uptake by the macrophytes. Food chain relationships from migrating waterfowl to other components in the marsh are indicated by a zero because it could not be established if other components in the marsh utilize migrating waterfowl for food. However, food sources leading to migrating waterfowl can be found in the vertical column (11).

Perhaps more important than first order (direct) food links are the indirect food chain interdependencies among the system components. These are determined by powering the matrix to the level of interdependency required (e.g., A^2 = 2nd order; A^3 = 3rd order, etc.). Table 2.6 illustrates the 2nd order food chain relationships in the marsh. For example, there exist three 2nd order food chain links from periphyton (1) to birds (10). These links can be charted through the model. They include:

periphyton → insects → birds;
periphyton → fish → birds; and
periphyton → benthic invertebrates → birds.

As expected, the matrix shows that more indirect links exist with components higher in the food chain. For example, birds have 37 2nd order food chain interdependencies with various components in the marsh. Similarly, large mammals and reptiles have 31 compared with components lower in the food chain such as zooplankton (0), submerged macrophytes (4), and insects (8). This observation is much more explicitly described in the 3rd order food chain

Table 2.6 Second order food chain relationships in a grassy marsh community (from Knight 1983).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	0	0	0	0	3	0	1	3	1	2	2	3	2	0	0
2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3	0	0	1	1	1	1	1	0	1	2	1	2	2	2	1	1	0
4	0	0	1	1	1	1	1	0	1	2	1	3	2	2	1	1	0
5	0	0	1	1	1	1	2	0	1	3	1	3	2	3	1	1	0
6	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	0	0	2	0	2	1	2	0	1	0
8	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
9	0	0	0	0	0	0	3	0	1	6	1	5	2	5	1	1	0
10	0	0	0	0	0	0	1	0	0	4	0	3	1	2	1	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0
13	0	0	0	0	0	0	0	0	0	2	0	2	1	1	0	1	0
14	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	1	0
15	0	0	0	0	0	0	1	0	0	3	0	2	1	2	0	1	0
16	0	0	0	0	0	0	2	0	0	5	0	4	1	4	0	1	0
17	0	0	0	0	0	0	1	0	3	3	3	1	0	2	0	0	4
Total	0	0	4	4	4	4	18	0	8	37	8	31	17	31	7	10	4

relationships. For example, there exists three 3rd order (indirect links) from storage (17) to insects (9). These include:

storage → floating macrophytes → insects → insects;
storage → emergent macrophytes → insects →insects; and
storage → submerged macrophytes → insects → insects.

The reason insects are in the 2nd and 3rd order food chain is that some insects utilize others for food sources as indicated in the model.

The matrix also indicates the high number of 3rd order indirect links among the higher order components in the marsh including birds (134), large mammals (114), and reptiles (105).

In fact, a linear relationship exists in 2nd and higher order relationships. As illustrated in Table 2.7, birds have the most diverse food chain interdependencies, with over 400 indirect links in the 4th order. Similarly, large mammals have 373 indirect linkages. This would suggest that these components utilize a variety of food sources. However, it should be pointed out that these are generalized food chain relationships. As such, the number represented here should not be considered definitive because in a real system the food web for species is more complicated and species may utilize food sources in other areas.

Cultural stresses can also be examined in a matrix format to analyze how they interact in food chain interdependencies in the Grassy Marsh. Four different types of cultural stresses were selected for matrix analysis including causeway, microcontaminants, wildlife viewing, and exotics (e.g., Eurasian milfoil in the submerged macrophyte component). The causeway was selected because it is a major stress initially influencing the most components in the marsh. Micro-

Table 2.7 Fourth order food chain interdependencies in a grassy marsh community (from Knight 1983).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	0	0	0	0	11	0	1	37	1	33	17	28	4	13	0
2	0	0	0	0	0	0	1	0	0	2	0	2	1	2	0	1	0
3	0	0	4	4	4	4	13	0	4	37	4	35	19	30	6	13	0
4	0	0	4	4	4	4	13	0	4	37	4	36	20	31	6	14	0
5	0	0	4	4	4	4	15	0	4	44	4	42	23	36	7	16	0
6	0	0	4	4	4	4	4	0	3	7	3	8	6	7	3	3	0
7	0	0	0	0	0	0	5	0	0	19	0	18	9	15	2	7	0
8	0	0	0	0	0	0	2	0	0	7	0	6	3	5	1	2	0
9	0	0	0	0	0	0	15	0	1	53	1	49	25	41	1	18	0
10	0	0	0	0	0	0	6	0	0	25	0	23	12	18	4	8	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	2	0	0	8	0	8	4	7	0	4	0
13	0	0	0	0	0	0	4	0	0	16	0	15	7	12	2	5	0
14	0	0	0	0	0	0	3	0	0	12	0	11	5	9	1	4	0
15	0	0	0	0	0	0	6	0	0	23	0	21	10	17	3	7	0
16	0	0	0	0	0	0	9	0	0	35	0	33	17	27	5	12	0
17	0	0	0	0	0	0	17	0	15	46	15	33	13	34	6	7	16
Total	0	0	16	16	16	16	126	0	32	408	32	373	191	319	57	134	16

contaminants (pollutants) were examined to illustrate possible biotransfer in the ecosystem. Wildlife viewing represents a culturally induced stress influencing the structure of the marsh.

A second matrix (B), see Table 2.8, is defined linking cultural stresses to the components of the marsh ecosystem. To calculate the kth order food chain interdependencies between cultural stresses and components, one can apply the following formula from graph theory:

$$B^k = B^{k-1} A$$

where:

B^k = kth order interdependency matrix;

B^{k-1} = k-lth interdependency matrix;

A = matrix of 1st order relationships; and

k = level of interdependency, i.e., 2, 3, 4 . . . .

Thus matrix B^k is obtained multiplying the original matrix A by the B^{k-1} matrix to calculate 2nd, 3rd, and 4th order food chain interdependencies interacting with the causeway, microcontaminants, wildlife viewing, and exotics

The matrices indicate that, by the 3rd order, the causeway may indirectly link with all food chain components of the ecosystem except periphyton,

Table 2.8 Higher order food chain interdependencies including selected cultural stresses in a grassy marsh community (from Knight 1983).

First order interdependency																		Total
1	0	0	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	11
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	0	0	1	1	2	1	0	0	0	2	0	1	1	1	1	1	2	

Order of interdependency = 2																		Total
1	0	0	1	1	1	1	3	0	3	8	3	6	2	6	1	1	4	41
2	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	4
3	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	4
4	0	0	0	0	0	0	1	0	1	1	1	0	0	1	0	0	1	6
Total	0	0	2	2	2	2	4	0	4	9	4	7	3	8	1	2	5	

1 = **Causeway,** 2 = Microcontaminants, 3 = Wildlife Viewing, and 4 = Exotics

phytoplankton, and zooplankton. By the 4th order, there are as many as 93 indirect food chain relationships associated with birds and other components in the marsh which may indirectly link with the causeway.

The matrices in Table 2.8 also show how microcontaminants initially only link with storage in the 1st order. However, by the 4th order, microcontaminants may link with most of the components in the marsh. Thus biotransfer in the food chain can be calculated in the matrix and charted in the model. For example, in the 1st order microcontaminants are transported to marsh sediments (1st order), absorbed by the macrophytes (2nd order), and transmitted to other components in the marsh, e.g. fish (3rd and 4th order).

Wildlife viewing initially interacts with birds in the 1st order by altering or influencing nesting behavior. This may subsequently alter food chain relationships with other components such as large and small mammals, reptiles, and benthic invertebrates in the 2nd order. Furthermore, by the 4th order, wildlife viewing may indirectly influence food chain relationships via feedback loops, birds, and large mammals (8 times) and reptiles (7 times).

By examining the vertical column totals of Table 2.8 the total number of indirect food chain relationships by components (e.g., birds) that may interact with all the selected cultural stresses is determined. For example, by the 4th order birds have the most indirect linkages (124), followed by large mammals (107), reptiles (98), and fish (43).

The horizontal column totals of Table 2.8 indicate a total number of food chain interdependencies of all the components that interact with each cultural stress. For example, in the 1st order the causeway directly links with a total of 11 components of the marsh. In fact, in all subsequent higher orders the causeway indirectly influences the most components within food chain interdependencies (e.g., 421 by the 4th order).

Microcontaminants initially interact with one component (storage-No. 17) in the 1st order but may be transported throughout the marsh system and interact with up to 60 indirect food chain relationships by the 4th order. Similarly, wildlife viewing initially interacts with one component but subsequently may interact (modify) other food chain patterns in higher order relationships. An exotic such as Eurasian milfoil in the 1st order directly influences the trophic structure in one component (submerged macrophytes) and may subsequently influence energy flows in higher food chain patterns, e.g., 68 by the 4th order.

2.3.5 Uses of the Conceptual Model

These conceptual models are intended as a first step in organizing, integrating, and interpreting existing information and understanding of the structure and function of the Long Point ecosystem. By including within its scope a set of natural processes and cultural stresses interacting with a variety of biotic communities, it reflects some management-oriented interests of organizations dealing with the Long Point ecosystem.

The model could therefore be used for purposes similar to those served by techniques developed for adaptive environmental assessment and management (e.g., Holling 1978; Environment Canada 1982). In lieu of reliable (and expensive) computer simulations, it substitutes visual diagrams that could be used to focus attention on the different perceptions of scientists, resource managers, and resource user groups about the Long Point ecosystem and the ways in which it seems to work.

The conceptual model can also be used as a basis for examining more closely the extent to which the different aspects of these images of how the Long Point ecosystem functions are based on documented evidence, sound theoretical principles, or informed intuitions. This would assist with the necessary scoping activities now recognized as essential for sound environmental impact assessments (Beanlands and Duinker 1983) should developments affecting the Long Point ecosystem be proposed. It would also direct priorities for undertaking management-oriented ecological research and environmental monitoring needed for sensitive and effective management of this ecosystem.

3. POLICIES, PROGRAMS, AND ADMINISTRATIVE ARRANGEMENTS

The relative ease and effectiveness with which an additional management strategy can be adopted depends on its compatibility with policies and program commitments of public agencies and non-governmental interest groups who would have to be willing to accept and use it. The Long Point complex is under the administrative management or use of several administrative agencies at four distinct levels of government. In addition, there is a private component characterized by a relatively large number of owners of small farms on the mainland waterfront and of properties, many on Long Point itself, held mainly for recreational purposes. Given the dominant role of government in decisions affecting the overall complex, the public sector was the main focus of the policy analyses undertaken to judge the practical feasibility of introducing the rehabilitative management perspective into the existing arrangements. Emphasis here will be on the aquatic components of the Long Point ecosystem.

The first section of this chapter reviews the standing structure of governmental institutional arrangements as these might be drawn upon to implement an ecosystem management strategy. The second section reviews the management goals and objectives reflected in 21 current or recent policy documents prepared by agencies administering plans or programs applying to the Long Point area. The third section reviews the program activities under way in the Long Point area as they relate to managing eight of the more important ecosystem stresses. The fourth section reviews briefly some policy instruments that could enhance ecosystem protection.

3.1 The Formal Responsibilities of Government Agencies

3.1.1 Approach to the Review

To understand better the existing standing structure of governmental institutional arrangements through which any ecosystem rehabilitation strategy would have to be implemented, we reviewed formal mandates and responsibilities of government agencies operating in Ontario. The point of departure for this review was the 18 categories of ecosystem stresses identified as affecting the Great Lakes (Francis et al. 1979). With reference to each of these stresses, government agencies having some formal statutory responsibility for dealing with one or more remedial measures were identified from annual reports of agencies, statutes, other reference materials, and selected interviews.

For purposes of the review, the 18 ecosystem stress categories were grouped into those related to the direct use of water resources and fishing, and those related to land use and shoreline development activities (Table 3.1). Some 26 primary stresses were identified in Table 2.3 above; 8 of these have been deleted for present purposes because we judged them to be less important than the 18 listed here.

The main responsibilities of government agencies were classified as follows:

- Enforcement of Regulations includes the development of regulations under statutes, preparing specifications for and administration of permit systems, and various related monitoring and enforcement activities (Table 3.2).
- Direct management function refers to various resource or environmental management practices carried out by agencies themselves. It is separated from administrative roles dealing only with funding or regulating activities of others, even though these may be viewed as management in a more general sense (Table 3.3).
- Funding responsibility other than that implicit in direct management refers to the administration of subsidies and grants to other agencies or groups for carrying out activities related to some remedial program (Table 3.4).

Table 3.1 Ecosystem stresses considered in the review of agency mandates

Habitat distruption. Covers an array of direct human impacts on aquatic ecosystems from water uses which could degrade habitats or water quality not covered under other water-use related stresses listed below.

Harvest. Impacts from fishing and other harvesting of biota.

Exotics. Introduction (accidentally or deliberate) and invasion of species which are not native to the Great Lakes.

Entrainment. Impingement and entrainment at water intake structures.

Water levels. Impacts from water level control for shipping, electrical power production, wetland management, etc.

Ice control. Ice control for winter navigation purposes mainly

Toxics. Microcontaminants, toxic wastes, and biocides from industry and agriculture.

Nutrients. Nutrients from sewage plants, agricultural, and urban runoff that cause eutrophication.

Sediment. Sediment loading and turbidity, from agriculture, construction sites, and resuspension.

Organics. Organic inputs and oxygen demand from sewers, canneries, etc

Air pollution. Acids and toxic chemicals transported by the atmosphere

Streams. Stream modification, dams, channelization, and logging, changes in land use.

Landfill. Filling, shoreline structure, offshore structure

Dredging. Dredging and mineral, sand, gravel, and oil extraction.

Drainage. Dyking and draining of wetlands.

Thermal. Thermal loading from cooling water, mostly in electric power plants

Weather modification. Occasionally, from industrial sources

Accidents. Major degradative incidents or catastrophe.

- Planning function refers to longer-range sectoral and/or spatial (regional) planning activities, and to statutory planning responsibilities (Table 3.5).
- Other supporting activities generally refer to research and data gathering, advisory services, public information, and education (Table 3.4).
- Coordination activity was noted separately to identify important interagency or intergovernmental coordination mechanisms which have already been set up.

From the information compiled, matrices were prepared to tally the distribution of responsibilities among agencies at each level of government for each of the stress categories. The resulting inventory of who officially is responsible for what can be viewed as a map of the standing structure of institutional arrangements. Its main use is as a reference for identifying particular agencies that might have to be involved or for indicating how they could become involved in helping to implement a coherent and sufficient rehabilitative management strategy for some area of interest. It should be noted that such a strategy may involve additional agencies to those readily recognized as playing key roles.

Table 3.2 Government agencies responsible for the enforcement of regulations

Agencies by jurisdiction	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediment	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather	Total by agency
	Ecosystem stress categories																		
Bilateral																			
Federal																			
Fisheries & Oceans	X	X	?	X			x	x	x	x		x	x	x	x	x	x		13, 1?
Environment	X						x	x			xx			x					6
Transport	X						?						x	x			?		3, 2?
Agriculture	X						x	x											3
Health & Welfare	X	X					X												3
Energy, Mines, & Resources	X													X			X		3
Public Works									X										1
Provincial																			
Environment	X			X			x	x		x	x	x		x			X		9
Natural Resources	x	x	x									x	x	x			X		7
Consumer & Commercial Relations							X										X		2
Agriculture & Food	X						X												2
Regional																			
Conservation Authorities									X			X							2
Local Municipalities														X					1
Total by stress	9	3	1 1?	2	0	0	7 1?	4	3	2	2	5	3	7	1	1	5 I?		55 3?

3.1.2 Results of the Review

Tables 3.2 to 3.8 summarize the results of this review. The matrices should be interpreted with some caution. First, whether or not a particular agency has formal responsibilities for some of the stress categories can be a matter of considerable difference of view, even among senior personnel within a given agency. This arises in part because the institutional arrangements being discussed were not devised specifically for ecosystem rehabilitation; hence there remain a number of uncertainties about how existing mandates and responsibilities might be interpreted in this new context. Second, the formal division of responsibilities among government agencies does not necessarily reflect the nature, thrust, and extent of their actual program activities. Some statutes may be relatively unused, whereas the interpretation of others may be narrowed as a result of budget restriction, policy decision, political preferences, or judicial interpretations. Agencies may also adopt a restricted set of technical activities related to their

Table 3.3 Government agencies with direct management responsibilities.

Agencies by jurisdiction	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediment	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather	Total by agency
	Ecosystem stress categories																		
Bilateral																			
IJC					X														1
GLFC			X																1
Federal																			
Environment					x	x	x			X				?	x			X	6, I?
Fisheries & Oceans			X																1
Transport	X				x	x						x	x				X		6
Public Works	X				X								x	x					4
Provincial																			
Environment	X						xx			x							X		5
Natural Resources	x	x	x				X					X			X				6
Agriculture & Food							?	?	?			X			X				2, 3?
Housing								x	x	x		X							4
Ontario Hydro	X			X	X	?										X			4, 1?
Transport												x		x					2
Regional																			
Conservation Authorities	X											x	x	x	x				5
Regional Governments	X			X			?	x	x	x			x		x		x		8, 1?
Local Municipalities	X			X			x	x	x	x		xx			x		x		10
Total by stress	8	1	3	3	5	2 1?	4 2?	4 1?	3 1?	5		7	5	3 1?	6	1	4	1	65 6?

limited professional expertise. Third, matrix formats tend to exaggerate the sense of fragmentation of responsibilities because this format cannot easily indicate the relative strength and continuity of each agency's involvement nor the various informal coordination mechanisms which may be in effect. Fourth, a number of agencies do not interpret their responsibilities explicitly in terms of Great Lakes issues even though some of their activities might or could have a bearing on ecosystem stresses. This is especially true for agencies dealing with land use. Hence, it is not always easy to get confirmation or a clear interpretation about some potential roles because there may not have been occasion to interpret formal statutory responsibilities explicitly in the context of the Great Lakes.

By way of summary, and keeping the above interpretive cautions in mind, some 64 Federal and Provincial statutes appear to have a bearing on one or more of the 18 categories of ecosystem stresses. Some 43 of these authorize direct regulatory measures whenever the others authorize supportive, facilitative mea-

Table 3.4 Government agencies providing support funding to other agencies or groups

Agencies by jurisdiction	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediments	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather	Total by agency
	Ecosystem stress categories																		
Bilateral																			
Federal																			
Environment	X						xxx				xx				xx			X	9
Fisheries & Oceans		X																	
Agriculture	?								X										1,1?
Transport													x	x					2
Public Works													x	x					2
Revenue							X	?	X		x								3,1?
Regional Economic Expansion	X						x	x	x	x		x			X				7
CMHC								x	x										2
Health & Welfare							X				X						X		3
Energy & Mines				?							X			X					2,1?
Provincial																			
Environment								X											1
Natural Resources		X							X						X				3
Agriculture & Food									x			?			X				2,1?
Housing								?	?										2?
Treasury							X						X						2
Regional																			
Local Municipalities																			
Total by stress	2 1?	2	0	0 1?	0	0	5	4 2?	7 1?	1	4	2 1?	3	4	4	0	1	1	40 6?

sures of various kinds. Federal and Provincial responsibilities seem about evenly divided in terms of the number of relevant statutes in each jurisdiction.

For an index of their relative importance for Great Lakes ecosystem rehabilitation, agencies may be grouped into two categories. The first or core group would be those having regulatory enforcement and/or direct resource management responsibilities. The second group would be agencies having only some facilitating or support functions such as planning, information gathering, or funding for activities carried out by others. From this point of view, the core group of agencies would consist of the IJC, seven Federal departments, seven Provincial ministries, the Conservation Authorities, and Regional and local municipalities. An inner core group, defined as agencies with assigned responsibilities covering 6 or more of the 18 stress categories would reduce this further to:

Table 3.5 Government agencies with responsibilities for sector and/or area planning

Agencies by jurisdiction	Ecosystem stress categories																		Total by agency
	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediment	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather	
Bilateral																			
Federal																			
Environment	x	x			X		x	x	x	?	x	x	x	x	x	x	x	x	14,1?
Fisheries & Oceans	?	?																	2?
Transport													x	x					2
Public Works	X								X				x	x					4
Health & Welfare	X						X				X						X		4
Energy, Mines, & Resources											X			X					2
Defense																	X		1
Provincial																			
Environment	X							X									X		3
Natural Resources		x	x	x											X				4
Housing							x	x	x	x	x	x	x	x					a
Transport												?		X					1,1?
Regional																			
Conservation Authorities	X												x	x	x				4
Regional Governments	X			X			x	x	x	x		x	x	x	x		X		11
Local Municipalities	X			X			x	x	x	x		x	x	x	x		X		11
Total by stress	7 1?	2 1?	1	3	1	0	5	5	5	3 1?	4	4 1?	7	9	5	1	6	1	69 4?

Canada Department of Fisheries and Oceans,
Environment Canada,
Transport Canada,
Ontario Ministry of the Environment,
Ontario Ministry of Natural Resources,
Ontario Conservation Authorities, and
Regional and Local Municipalities.

In practice, the main responsibilities of the Department of Fisheries and Oceans have been transferred to the Provincial government by delegating the administrative responsibilities under the Federal Fisheries Act concerning fisheries management to OMNR.

Another way of summarizing the institutional arrangements is by the distribution of the various kinds of responsibilities undertaken by government

Table 3.6 Government agencies responsible for other supporting services.

Agencies by jurisdiction	Ecosystem stress categories																		Total by agency
	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediments	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather	
Bilateral																			
IJC	X				X		x	x	x	x	x	x		x	x				10
GLFC		x	x																2
Federal																			
Environment	X				x	x	x	x	x	x	x	x	x	x	x	?	x	x	14,1?
Fisheries & Oceans	x	x	x	x	X						X								6
Agriculture	X						xx			x									4
Transport	X												x	x					3
Public Works						X			X				x	x					4
Regional Economic Expansion	X						x	x	x	x		x			X				7
CMHC								x	x										2
Health & Welfare	x	x					X				X						X		5
Energy, Mines, & Resources	X			X							X			X			X		5
Industry, Trade, & Commerce																			1?
Provincial																			
Environment	X			X		?	x	x	x	x	x	x	x	x		x	x		12,1?
Natural Resources	x	x	x	x		?		xx		x	x	x	x	x	x	x			13,1?
Food & Agriculture							x	x	x	x		x			X				6
Consumer and Commercial Relations							X												1
Hydro/Energy			X	X										X			X		4
Labor							X												1
Regional																			
Conservation Authorities								x	x			x	x						4,1?
Local Municipalities																			
Total by stress	10	4 ?	3	5	4	2 2?	10	9	8	7	7	7	6	8	5 ?	2	5	1	103 4?

across all of the stress categories. They can be listed in order of the relative strength of function as follows:

Enforcement of regulations	55 (plus 3?),
Direct resource management	64 (plus 6?),

Funding support for others	40 (plus 6?),
Sectoral or spatial planning	69 (plus 4?),
Other supporting measures	103 (plus 5?).

This listing suggests that a little over one-third of the functions are represented by activities related to regulatory enforcement and direct resource management. By way of comparison, about one-seventh of all functions were in these two categories in a similar tally done for Green Bay (Harris et al. 1982). This would seem to reflect differences in the institutional arrangements of the two countries. With a more hierarchical and much less pluralistic public sector, Canada places relatively more emphasis on the direct implementation of program measures by government and proportionately less on devices intended to encourage cooperation and consensus building among diverse agencies and non-governmental constituencies.

The main coordinating mechanisms for use in Great Lakes ecosystem rehabilitation in Canada are the binational arrangements represented by the IJC and the GLFC, and three Federal-Provincial agreements: the Strategic Plan for Ontario Fisheries; the Canada-Ontario Agreement Respecting Great Lakes Water Quality, and the Canada-Ontario Accord for Protection and Enhancement of Environmental Quality. There are a number of interdepartmental groups within both Federal and Provincial jurisdictions.

3.1.3 General Conclusion

The general conclusion drawn from this review was that there appeared to be no major gaps in the standing structure of arrangements. Existing arrangements seem to be better organized functionally for some stresses related directly to water uses compared with those related to land uses. This in turn is probably due to the specific Federal-Provincial arrangements for implementing programs under the aegis of the two binational commissions. We need a comparable effort to address impacts of land use activities on the Great Lakes nearshore ecosystems; the recommendations in the report on pollution in the Great Lakes from land use activities (IJC/PLUARG 1980) could support and facilitate ecosystem rehabilitation.

The information gathered by this first review should be corrected or revised in the context of devising a particular ecosystem strategy for selected geographical areas within the Great Lakes such as the Long Point area. This would allow specific rather than hypothetical questions to be asked of various agencies about their actual activities and perceived responsibilities for given situations.

3.2 Policy Documents Applicable to the Long Point Ecosystem

In that it appeared that no serious gaps existed in the standing structure of governmental institutional arrangements, a review was then made of policy documents that guide various resource and environmental management programs in the Long Point area. The purpose was to examine the compatibility of the various existing commitments to the management approach advocated by the Great Lakes Ecosystem Rehabilitation working group.

Table 3.7 Federal statutes relating to ecosystem stresses.

Statutes	Ecosystem stress categories																	
	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediment	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather
Atomic Energy Control	X													(X)			X	
Canada Shipping	X																X	
Canada Water	(X)				(?)				X						(X)			
Clean Air											X							
Environmental Contaminants	X							X				X						
(Farm Credit Corporation)										(X)								
Fertilizers									X									
(Fish Inspection)			(?)															
Fisheries	x	x	x	x				x	x	x	x		x	x	x	x		xx
(Fisheries Development)		(X)																
(Fisheries Price Support)		(X)																
Food & Drug		X																

Government Harbors & Piers	(?)										X	(X)				
Harbors Commission	(?)										x	x			X	
(Income Tax)							(X)	(X)	(X)	(X)						
(Motor Vehicle Safety)										(X)						
National Energy Board											(X)				(X)	
(National Housing)								(?)	(?)							
Navigable Waters Protection												x	x			
Nuclear Liabilities														X		
Pest Control Products	X		(X)				X									
Public Works						(?)						x	x			
Railway							(X)								X	
(Small Craft Harbors)		(X)														
St. Lawrence Seaway	(?)			(?)	(?)										X	
(Transport)	(?)			(?)	(?)											
Transport of Dangerous Goods							(?)								X	
Weather Modification Information																X
Hazardous Products Act							(X)									
Shipping			(?)													
Boundary Waters Treaty				X												
Niagara River Treaty				X												
Agricultural Rehab. & Development								(X)	(X)				X			

Regulatory, 23; Facilitative, 10; total, 33.

Table 3.8 Provincial statutes relating to ecosystem stresses.

Statutes	Ecosystem stress categories																	
	Habitat	Harvest	Exotics	Entrainment	Water level	Ice control	Toxics	Nutrients	Sediment	Organics	Air	Streams	Landfill	Dredging	Drainage	Thermal	Accident	Weather
Beach Protection												X	X	X	X			
Beds of Navigable Waters												X		X				
Conservation Authorities	(X)							(X)	(X)	(X)		X	X	X	X			
Crown Timber												X						
Drainage									X			X			X			
Energy																(?)	X	
(Environmental Assessment)	(X)		(?)	(X)			(?)	(?)	(X)	(X)	(X)	(X)		(X)				
Environmental Protection	X						X	X		X	X			X			X	
Fish Inspection		X																
(Forest Tree Pest Control)							(X)											
Game and Fish		X					(?)											

(Housing and Development)									(X)								
Lakes and Rivers Improvement	X											X		X			
Mining	(?)													X			
(Municipal)								(X)	(X)	(X)	(X)	(X)	(X)	(X)	(X)		(X)
(Ontario Land Corporation)								(X)	(X)	(X)		(X)					
Ontario Water Resources	(X)			X			X	X		X				X			
Pesticides	X		?				X										
Petroleum Resources	(?)													X			X
Pits and Quarries														X			
(Planning)							(?)	(X)	(X)	(X)	(X)	(X)	(X)	(X)	(X)		(X)
(Power Commission)				(?)													
Public Health										X							
Tile Drainage									X			X			X		
Weed Control							X										
(Woodland Improvement)												(X)					
(Fishery Loans)		(X)															
Gasoline Handling Act							(X)										X
Public Lands												X		X			
(Shoreline Property Assistance)													(X)				

Regulatory, 20; facilitative only, 10; total, 30.

3.2.1 Documents Reviewed

The evidence used for this review was a set of 21 documents pertaining to resource and environmental planning and management applicable to the Long Point area. The status and specificity of these documents varied. Some are official policies, others are provisional policies subject to modification in light of public discussion, some are official documents but the policy implications had to be inferred from supporting or related statements, or from the actions associated with them. The documents reviewed are listed with brief annotations in Table 3.9.

Table 3.9: Annotated list of policy documents grouped by the relative extent of the geographic area covered. Status noted.

Binational, Great Lakes Basin

1. Canada-United States Great Lakes Water Quality Agreement, IJC, 1978. (official policy)
   - Commitment to establish ecosystem quality objectives and take necessary measures to meet and maintain them; progress monitored through Great Lakes Water Quality Board, and particular issues studied by Science Advisory Board, reporting to the IJC.

2. International Joint Commission, Lake Erie Regulation Study Board, 1981. (inferred policy)
   l Reference study following up Great Lakes Levels study of 1974 concluded that further measures to regulate levels of Lake Erie are not feasible.

3. Great Lakes Fishery Commission, 1980a. (official policy)
   l Adopted policy to promote ecosystem management for the Great Lakes and demonstrate leadership for this with respect to fish and related habitat features.

4. Joint Strategic Plan for Management of Great Lakes Fisheries developed under the auspices of the Great Lakes Fishery Commission, 1980b. (official policy)
   . Framework for cooperation among fishery management agencies of 11 Federal, Provincial, and State jurisdictions to work toward goals stated in the Plan.

5. The Migratory Birds Convention Act (Government of Canada 1917). (official policy)
   - Governs Canadian commitments under Migratory Birds Convention, including management of waterfowl and habitat in Lake Erie and the Long Point complex.

Federal-Provincial, Canadian Great *Lakes Basin*

6. Canada-Ontario Accord for the Protection and Enhancement of Environmental Quality, 1975. (official policy)
   - Framework agreement to provide effective Federal-Provincial cooperation on pollution control and environmental impact assessments.

7. Canada-Ontario Agreement Respecting Great Lakes Water Quality, 1982. (official policy)
   l Agreement "to renew and strengthen" Federal-Provincial cooperation to fulfill obligations of Canada under the Great Lakes Water Quality Agreement and ''. develop a better understanding of the Great Lakes Basin Ecosystem."

8. Strategic Plan for Ontario Fisheries, Ontario Ministry of Natural Resources and Canada Department of Fisheries and Oceans, 1976. (semi-official policy)
   - Federal-Provincial plan that provides measures to help rehabilitate fisheries in southern Ontario; administered by the OMNR.

Southern Ontario

9. Southern Ontario Co-ordinated Program Strategy, Ontario Ministry of Natural Resources, 1982. (official policy)
   - OMNR stated goals and objectives for land use and resource management in Southern Ontario.

10. Food Land Guidelines, Ontario Ministry of Agriculture and Food, 1978. (policy inferred)
    - Guidelines prepared by OMAF for use by land use planners in regions, counties and municipalities.

11. Agricultural Code of Practice, 1976. (policy inferred)
    - Guidelines prepared by the Ontario Ministries of Agriculture and Food, Environment, and Housing for "comprehensive manure management plans for all livestock operations" and "to control water pollution caused by livestock watering at streams, ponds or lakes."

The Long Point Region

12. Simcoe District Land Use Guidelines, 1983. (official policy)
    - OMNR guidelines set in the context of its Southern Ontario Co-ordinated Program Strategy.

13. Regional Plan for the Haldimand-Norfolk Planning Area, 1980. (official policy)
    - The approved official policies plan for the Regional Municipality; contains policy provisions for recognizing and protecting Long Point ecosystems as "environmentally sensitive areas."

14. Long Point Region Conservation Authority, 1983, Watershed Plan. (official policy)
    - Goals, objectives, strategies, and programs for soil and water conservation and related resource uses for eight watersheds draining over 2,750 km^2.

15. Nanticoke environmental quality monitoring arrangement. (policy inferred)
    - Joint industry-government monitoring of aquatic environmental quality near the Nanticoke industrial developments since 1968 by the Nanticoke Environmental Committee, and of air quality since 1978 by the Nanticoke Environmental Management Program.

16. Township of Norfolk, 1980, District Plan. (official policy)
    - Township official plan prepared to conform with Regional Plan for Haldimand-Norfolk

Specific Components of the Long Point Ecosystem

17. Long Point National Wildlife Area, Management Plan, Canadian Wildlife Service, 1983. (official policy)
    - Goals, objectives, and policy provisions to provide a high degree of protective management for 3,250-hectare portion of the Long Point ecosystem.

18. Big Creek National Wildlife Area, Canadian Wildlife Service, 1982. (inferred policy)
    - Concept plan and management plan under preparation.

19. Long Point Crown Marsh Management Plan, Ontario Ministry of Natural Resources. (provisional policy)
    - Draft management plan under provisions of the Simcoe District Land Use Strategy.

20. Turkey Point Provincial Park, Master Plan, Ontario Ministry of Natural Resources, 1981. (official policy)
    - Statement of goals, objectives, and policy provisions for a Recreation Park administered by the OMNR.

21. Long Point Provincial Park. (policy inferred)
    - Goals and objectives stated for master plan under preparation for a Recreation Park.

3.2.2 Determining Goals and Objectives

Because the documents listed above differ so greatly in their status, scope, focus, scale, and specificity, there was a need to develop a systematic approach toward analyzing their stated or implied goals and objectives. Goals in this context refer to broad statements of social purpose that the management activities are intended to serve; objectives are more explicit statements of means or outcomes that contribute toward fulfillment of goals.

The societal goals pertaining to planning and management for the Long Point area were noted by Regier et al. (1980), who adapted goals previously developed in reviews of fishery management documents (e.g., Mackenzie 1974; Loftus et al. 1978) to make them more fully relevant to Great Lakes ecosystem rehabilitation as follows:

- Ensure Environmental Harmony
    - Protect, conserve, and rehabilitate unique components, harvestable and non-harvestable resources of the ecosystem.
    - Ameliorate hazardous or unpleasant environmental conditions.

- Ensure Material Well-Being
    - Stimulate and sustain regional economy and human sustenance through efficient and equitable use of environment and resources.

- Ensure Cultural Opportunity
    - Foster and maintain human health, abundant high-quality recreation, diverse cultural options with equitable access, and human heritage.

Besides these three societal goals, a fourth goal was discernible in the documents reviewed:

- Accomplish Reforms in Governance
    - Strengthen interorganizational cooperation,
    - Involve relevant publics much more in decision processes,
    - Make the normative context for particular government actions more explicit for accountability and other purposes.

Each goal subsumes a number of objectives, and about 20 objectives were identified in the documents reviewed. In some documents, the definition of objectives was not always evident. To help determine whether an objective was present or not, we prepared a list of key words or concepts that constituted descriptors of each objective. These provided criteria for a reasonably standard interpretation of the inclusion and meaning of objectives found in these various documents. The goals, objectives, key words, and concepts linked to objectives are presented in Table 3.10.

Ideally, planning and management actions proposed in policy documents should be guided by goals that express the outcome of program activities. In

Table 3.10 Goals, objectives, and key words or concepts used to identify objectives in the policy documents reviewed

Goals and objectives of agency plans	Key words and concepts addressed in agency plans
Environmental harmony	
Protect unique species, landscape	endangered species, sensitive areas, natural areas, specialty use areas, non-game species, wetland protection
Conserve harvestable resources	protect fish or wildlife, guard integrity of water, provide harvestable resources, abundance of ground-water, forest maintentance, habitat protection
Rehabilitate harvestable resources	restore integrity of water, enhance habitat, reforestation, fish culture. restore wildlife populations
Reduce hazard damage	dangerous or harmful conditions, whether natural or human-induced, loss of life, physical injury, damage to property, flood, high water levels
Neutralize unpleasant conditions	odors, unsightliness, bad flavor, cosmetic landscaping
Material well-being	
Stimulate regional economic growth	promote new economic activities, produce locally useful by-products, create multi-purpose support structure, plan for forecasted growth
Improve efficiency of resource use	maximum net benefits, limited entry to resource harvest, reduce overcapitalization, optimization
Ensure equitable resource use	access to resource, fair allocation, consider interest group claims, quotas, balance resource use
Sustain economy	protect current economy, maintain level of resource use, support economic initiative
Provide employment	sustain employment or income levels, support labor intensive initiatives, create residential environment for new employees
Cultural opportunity	
Guard human health	health services, prevent or treat disease, contaminants, toxins, healthy human environment
Develop recreation	promote angling, hunting, boating, swimming, hiking, skiing, plan recreation centers, interpretive programs
Diversify cultural options	provide variety of opportunities, expand public interest, encourage exploration, facilitate range of activities, diverse zoning
Honor tradition	native resource use, heritage program, respect existing uses

Table 3.10 Continued

Goals and objectives of agency plans	Key words and concepts addressed in agency plans
Reforms in governance	
Exercise stewardship	entrench rights to resource use, custodial responsibilities, act on behalf of public
Understand change	monitor, surveillance, understand ecosystem, study, research
Facilitate accountability	open performance accountability, audit, regular review of activities, public record, environmental assessment, open discussion
Encourage public involvement	foster public appreciation, interest group involvement in management, create public awareness, extension services, citizen advisory group, public meeting, education
Coordinate agencies	coordinate planning, multi-jurisdictional participation, consensus, interagency planning, lead agency, co-sponsor
Advance binational relations	reaffirm spirit of friendship and cooperation, facilitate joint Canada-United States decisions, work toward common goal

other words, the set of objectives and goals, if achieved, would serve to create or accommodate a different mix of human and natural environmental conditions. With respect to ecosystem rehabilitation in particular, an expression of goals and objectives would clarify management intent much more clearly if they specified the cultural stresses being addressed, i.e., degradative human activities or products and the future environmental conditions sought, expressed in terms of appearance or impressions of the intended results of resource and environmental management.

3.2.3 Commentary and Conclusions

The extent to which the documents we reviewed identified stresses and expressed environmental futures is summarized in Tables 3.11 to 3.12. These interpretations are, of course, necessarily judgmental and subject to comment and revision. As indicated by the review of formal mandates and institutional arrangements, some agencies may not be addressing some objectives fully. Where goals and objectives are provisional or inferred they cannot fairly be said to be a complete indication of the intended commitment. Some implicit goals and objectives may not have been discerned because they were expressed in altogether too vague terms; some objectives subsumed by goal statements may never be explicitly expressed. It is sometimes possible to discern implicit objectives through descriptions of proposed program activities given in the text of a plan. In other words, statements on strategies and tactics imply the unstated objectives that comprise a goal.

None of the documents was fully comprehensive, although the Ontario Ministry of Natural Resources Strategic Plans and the Haldimand-Norfolk Regional Plan address the broadest range of goals and objectives. In general it appears that goals for environmental harmony and reform of governance to facilitate implementation efforts can be discerned in almost all the documents reviewed. Documents concerning the binational initiatives, however, do not address material well-being or cultural opportunity goals and objectives to the same degree as the others. Documents concerning parks or wildlife management plans address material well-being objectives only to a limited extent.

The geographic area covered by the documents reflects varying degrees of comprehensiveness and detail. Binational documents do not deal with specific designs for local situations, and local planning and management documents tend not to address broad societal interests.

Different cultural stresses in the Long Point area are acknowledged through goals and objectives contained in the documents reviewed; differences exist among documents addressing situations of similar scope and scale. Most resource and environmental management agencies do not express their intentions concerning cultural stresses in their statements of goals and objectives. Those stresses which are most frequently addressed in the various documents give helpful insights into which problems are perceived of greater importance. Thus, harvesting of biota, recreational activities, sediment loading and erosion, and dredging and physical extraction are major concerns reflected in a range of documents. Land filling and shoreworks, wildlife disequilibria, fire, and vegetation control tend to be only local worries. Nutrient loading, microcontaminants and toxins, air pollution, major degradative incidents, organic loading and flotsam and jetsam are more generalized and longer-term concerns. Some stresses (e.g., ice control, weather modification, and water diversions) were not mentioned in any of the goals or objectives in the documents examined, but are addressed by other management agencies more directly involved with them at the binational or provincial level.

Environmental images are more consistently addressed in statements of goals and objectives than are cultural stresses. The most frequent images are of cooperative planning; of sensitive land and water use; abundant fish, wildlife and trees; public access to resources; and multiple use of land. The images least often addressed are sufficient food for human populations; management using ecosystem level principles; and a healthy natural environment as an indicator of a healthy human environment.

No two documents expressed identical sets of goals and objectives according to the criteria we used to assess them, However, some portion of each set overlaps or is consistent with similar sets in each of the others. Although two goals are expressed by all the documents, no single objective is shared among them all. Nevertheless, there is a general compatibility among the goals and objectives being sought by agencies having resource and/or environmental planning and management responsibilities for Long Point ecosystems. Some

Table 3.11 Cultural stresses addressed in the policy documents reviewed.

Policy Document (Abbreviated titles, refer to Table 3.9)	Cultural Stresses																									
	Fishing and other harvesting	Recreational camping, hiking, swimming	Nutrient loading	Sediment loading, erosion	Modification of streams	Exotic species	Urban and cottage development	Dyking and draining wetlands	Microcontaminants and toxins	Landfill, shoreworks	Dredging, excavation (physical)	Wildlife disequilibria	Air pollution	Major degradative events	Organic loading	Fire	Shipping and boating (physical)	Thermal loading	Entrainment and impingement	Vegetation control	Water level control	Ice Control	Weather modification	Water diversion	Flotsam and jetsam	Migration hazards to birds
Binational																										
1. GLWQA of 1978			X	X					X				X	X	X			X							X	
2. IJC Lake Levels																					X					
3. GLFC Ecosystem Policy	X					X																				
4. Strategic Plan/GL Fisheries	X	X	X	X	X	X	X	X	X		X	X	X		X		X		X		X					
5. Migratory Birds	X											X														

Federal-Provincial																										
6. Environmental Accord									X				X		X											
7. GL Water Quality			x	x					X		X				X		x	x	x							
8. SPOF	X		x	x	x	x	x	x	x	x	x		x	x	x			X								
Southern Ontario																										
9. Coordinated Strategy	x	x		x	x			X								X										
10. Food Land Guidelines			x	x			x	x			X															
11. Agricultural Code			x	x											X											
Long Point Region																										
12. Simcoe District	x	x		x	x		x	x	x	x	x	x				x	x			X						
13. H-N Official Plan	x	x	x	x	x		X		x	x	x		x	x	x			X		X						
14. LPRCA Watershed Plan	x	x		x	x			X		X																
15. Nanticoke committees			x	x					x	x			X					x	x							
16. Norfolk Township		x	x	x	x	x				X																
Parts of Long Point																										
17. LP National Wildlife Area	X	X		X		X						X				X		X								X
18. Big Creek	x	x		X		X		X			x	x				X				x	x					X
19. LP Crown Marsh	x	x		X			X			x	x						X			X						
20. Turkey Point Provincial Park		X		X		X										X				X						
21. Long Point Provincial Park	X	X		x	x							X				X					X					

Table 3.12 Environmental images (futures) revealed by goals and objectives in the policy documents reviewed

Policy Document (Abbreviated titles, refer to Table 3.9)	Environmental images									
	Sufficient food	Easily accessible resources	Clean and abundant water	Cooperative planning	Sensitive land use and water use	Safe coastal zone and river basins	Healthy human environment	Ecosystem level management	Abundant fish, wildlife, and trees	Multiple use
Binational										
1. GLWQA			x	x	x			X		
2. IJC Lake Levels		X				X				
3. GLFC Ecosystem Policy	x	x	x	x	x		x	x	x	
4. Strategic Plan/GL Fisheries	X			x	x		X		X	
5. Migratory Birds									X	
Federal-Provincial										
6. Environmental Accord			x	x	x			X		
7. GL Water Quality			x	x	x			X		
8. SPOF	X			x	x		x	x	x	
Southern Ontario										
9. Coordinated Strategy				x	x	x			x	x
10. Food Land Guidelines	X									X
11. Agricultural Code					X					X
Long Point Region										
12. Simcoe District		x	x	x	x	x			x	x
13. H-N Official Plan	X		x	x	x	x	x		x	x
14. LPRCA Watershed Plan		X		x	x	x				
15. Nanticoke committees				x	x	x				
16. Norfolk Township			x	x	x	x	x			x
Parts of Long Point										
17. LP National Wildlife Area		x	x			x	x			
18. Big Creek	x	x	x			x	x	x		
19. LP Crown Marsh	x	x	x			X		X		
20. Turkey Point Provincial Park	X						X	X		
21. Long Point Provincial Park	X						X	x		

statements of goals and objectives are essentially the same or completely aligned with one another; others seem to constitute distinct but complementary sets. The policy documents also can indicate which among the agencies would seem to be natural allies for joint efforts in promoting more comprehensive approaches to ecosystem management.

Compatible goals and objectives at the level of policies do not automatically mean that differences of views or conflicts of interests will be absent among the agencies while they are implementing their policies. In summarizing, we note that not only is there a general convergence in the basic statements of intent in these diverse documents, but the convergence itself is compatible with the rehabilitative management approach advocated by the Great Lakes Ecosystem Rehabilitation working group.

3.3 Overview of Program Activities of Government Agencies in the Long Point Area

In the previous sections we noted that a number of different agencies, at four levels of government, have important planning and management responsibilities for the Long Point ecosystem. In this section we review the program activities of different agencies as they relate to eight human-induced stresses judged to be the most significant in terms of their effects on the ecosystem.

As already noted, a comprehensive list of stresses was identified during the March 1980 workshop, and stresses were at that time ranked in order of their perceived importance (Regier et al. 1980). The eight stresses discussed in this section were drawn from this list. They include the five ranked highest at the 1980 workshop and three others ranked somewhat lower. Those in between are omitted here either because they were significant in the past but of less current importance (e.g., shoreline cottage developments and the introduction of exotic fish species), or they are stresses that have to be dealt with on a basin-wide rather than only at the local level (e.g., control of toxic substances or the long-distance transport of air pollutants).

Information on the activities of agencies dealing with the Long Point area was obtained from various documents and from interviews with agency personnel carried out in late 1980 and 198 1 (Cheskey 198 1). The general patterns of these activities remains essentially the same early in 1985. The inherent limitation in gathering information from respondents whose perceptions, on occasion, seemed somewhat influenced by agency mandates or positions is acknowledged. Nevertheless, by cross-checking with other sources it was possible to identify the main agency activities dealing with different aspects of the eight stresses reviewed here.

3.3.1 Commercial and Sport Fishing Harvest

Situation: Although more serious in the past, overfishing is potentially still a significant stress. This is evidenced by suppression of large, valued fish species such as whitefish, lake trout, and sturgeon, and by changes in species composition toward a greater abundance of less desirable species (Hartman 1973; Whillans 1985).

There are two commercial fisheries based in the Long Point area. One is geographically confined to the Inner Bay and operates from Port Rowan, and the other is a deep-water fishery operating out of Port Dover. Fishermen in the Inner Bay use hoop and seine nets to catch brown bullhead and mixed sunfish, including rock bass, bluegill, black crappie, and yellow perch; these fish are transported live to the United States where they are used to stock put-and-take ponds (D. Reid, pers. Comm.).

The fishery in the Outer Bay is of much greater magnitude. Fishermen trawl for rainbow smelt, of which 4.5 to 9 million kilograms have been taken annually in recent years (J. Paine, pers. Comm.). They also use gill nets primarily to capture yellow perch (Berkes 1983).

Recreational fishing is also very significant in this area. Smallmouth and largemouth bass are probably the most desirable sport fish sought in the Inner Bay, although other species such as yellow perch and rock bass make up the bulk of the catch. Spear fishermen take northern pike during the spring from the marshes of the Inner Bay (Hamley and MacLean 1979). During the winter, the Inner Bay is used extensively for ice fishing; yellow perch make up 99% of the catch (D. Reid, pers. Comm.). Coho salmon are taken by downriggers off the tip of Long Point in July and August. Rainbow smelt are also caught in large numbers in dip nets during spawning runs. Cold-water streams and stocked reservoirs on the mainland are fished primarily for brook trout.

Agency Activities: The OMNR is the only agency that exercises direct management, enforcement, and planning responsibilities for fisheries. These responsibilities derive primarily from the Canada Fisheries Act (delegated for administration to the Province), the Ontario Fishery Regulations drawn up under the Fisheries Act, and the Ontario Fish and Game Act.

For Long Point Bay the administrative responsibilities are divided among the London Regional Office, the Simcoe District Office, and the Lake Erie Fishery Assessment Unit based in Wheatley and Port Dover.

The Ministry has three main monitoring programs to collect data for fishery assessment and management decisions: (1) the index fishing program (designed to collect annual data in order to assess year class strength and population changes by determining age, size, sex, and number of fish caught); (2) commercial harvest monitoring (i.e., daily reports, submitted monthly, and annual reports on the volume of fish caught, particularly the main commercial species); and (3) sport fish monitoring (e.g., creel census, personal interviews) done primarily by OMNR's District Office at Simcoe. Aerial photography has been used in the past to determine the intensity of the sport fishery outside traditionally known areas. Data collected by these means are used locally by the District Office, the Assessment Unit, and the Lake Erie Management Committee.

The binational Lake Erie Committee of the GLFC analyzes data for percids to assess populations and determine interjurisdictional quotas under the binational Walleye Protocol (Berkes 1983; Grima and Allison 1983).

The OMNR has a variety of sport fishing regulations concerning closed and open seasons, licenses, catch limits, minimum size limits, possession limits, the type of fishing gear that can be used, winter fishing, the sale of fish, bait, and means of fishing other than angling and transporting fish.

The CWS, which administers the National Wildlife Area at Long Point, currently restricts and limits angling and other harvesting activities on some of their properties on Long Point. Since 1973, the northern pike season for commercial fisheries in Long Point Bay has been restricted to September 1 - May 12. Each of the 15 or so licences is limited to 455 kg per year, and the size of fish caught is limited to between 57 to 78 cm.

The logistical problems faced by fishermen (e.g., incidental and unavoidable capture of protected fish) make strict adherence to many of these regulations difficult. No new commercial fishing licenses have been issued for Long Point Bay for many years so that the number of fisheries remains constant or declines. However, the conventional method of controlling fishing intensity had limited value because OMNR had no control over the size of the fishing vessels or the sophistication of the gear with the result that overcapacity for fishing develops (Berkes et al. 1983).

The OMNR also carries out stocking programs in the study area. Catchable rainbow trout are stocked in ponds and reservoirs. Yearling rainbow trout are stocked in Young and Big creeks. Rainbow fry are placed in Young and Big creeks and the Lynn River. Some 10,000 to 15,000 brook trout are stocked, mainly for rehabilitation at several sites. The Simcoe District Office has recently stocked Big Creek with walleye, which have historically spawned there.

The Ministry is modernizing its approach to fisheries management through population modelling techniques, an improved data base, and the setting up of individual quotas (Grima and Allison 1983). Rehabilitation efforts have concentrated on trout populations, particularly brook trout. Current goals are to maintain a valuable commercial fishery and to enhance sport fishing.

3.3.2 Recreational Camping, Hiking, Swimming, Birdwatching, and Associated Activities

Situation: The Long Point area provides a number of opportunities for outdoor recreation, yet these have to be accommodated with severe limitations on public access. Much of Long Point itself is virtually closed to public recreation, and much of the rest of the area is occupied with intensive private cottage developments. The Long Point and Turkey Point provincial parks absorb much of the intensive public recreational activities, and a growing number of private marinas provide boat access for sailing and fishing. The spring and fall seasons draw birdwatchers, and private hunt clubs and crown marsh areas provide areas for waterfowl hunting in the fall.

The market area for camping and day visitors to the Long Point area falls largely within a 1.5-h drive of the parks (Cooper 1980); in 1976 about 2.7 million people lived within this camping market area. The population within the Regional Municipality is projected to grow from 87,000 in 1977 to about 170,000 in 2001. Although community and local outdoor recreation opportunities are also being developed, it is anticipated that the Long Point area itself will likely draw many local residents for day-use activities.

The stress effects on the ecosystem from the kinds of recreation considered here are not well understood. Stresses resulting from shoreline development works, dredging, fishing or potential overfishing, and minor incidents of oil spills or other polluting activities are understood more fully. Some of these are associated with recreational activities. The main concern of management agencies is that growing recreational uses for the Long Point area will lead to more incidents of illegal use of areas closed to the public, and to political pressures for recreation development in the more sensitive components of the ecosystems.

Agency activities: Considerable effort has been made in recent years to prepare management plans for components of the Long Point area administered by different agencies. Policy provisions for recreational use of the areas are an important component of the plans being prepared.

The CWS is proposing to provide restricted access, possibly by charter boats, to a tightly controlled walking trail at Gravelly Bay, and selected access to Squire's Ridge within the Long Point National Wildlife Area. The management plan being developed for the Big Creek National Wildlife Area will provide some public access to the marsh and possibly a Visitors Services Centre.

Long Point Provincial Park, although relatively small (about 141 ha) is at the end of the access road to Long Point, and absorbs a substantial volume of camping and day-use activities sandwiched between extensive private holdings. Turkey Point Provincial Park was created in 1959 largely to help draw off the heavy demand for the limited facilities at Long Point. The Long Point Crown marsh management plan is to provide an intensively managed waterfowl hunt for the general public as the dominant use. Elsewhere on the mainland adjacent to the point, the Ministry is proposing to add 720 campsites, 520 picnic tables, and 3,562 m of beach for public use over the next 20 years in Simcoe District.

The Long Point Region Conservation Authority has 25 Conservation Areas ranging in size from about 4 to 270 ha, most of which provide for day-use recreation. The Regional Municipality of Haldimand-Norfolk proposes to supplement the activities of these other agencies by promoting trail-oriented recreation activities, and the rehabilitation of pits, quarries, and regional landfill sites for possible recreational use.

3.3.3 Nutrients and Eutrophication

Situation: For many years Lake Erie waters were described as oxygen starved, eutrophied, and choked with blue-green algae, all symptoms of cultural pollution. Although such reports may have described with accuracy some sections of Lake Erie, particularly along the American shores of the Central and Western Basins, they do not apply to Long Point Bay.

Long Point Bay is a physically diverse area, containing some of the deepest and clearest waters of the Eastern Basin in Lake Erie, as well as the highly productive shallow waters of the Inner Bay. These waters have not entirely escaped cultural pollution. Phosphorus, a key growth-triggering plant nutrient when present in sufficiently high concentrations, enters Long Point Bay from a variety of sources. These include sewage treatment facilities on Lake Erie or its tributaries; industrial wastes; private cottage and waste disposal systems at Long Point, Turkey Point, and the Erie shoreline; and agricultural inputs from manure and chemical fertilizers.

Nutrients stimulate considerable growths of floating and filamentous algae and other aquatic plants. When these organisms die, their decomposition reduces oxygen levels in the water to anoxic and near anoxic levels, rendering once healthy waters inhospitable to many fish. This might now limit any efforts to restore whitefish and lake trout which likely spawned (or spawn) in the deep-water shoals off Long Point Bay. A recent increase in filamentous algae along some stream bottoms in the study area is attributed to nutrient input from agricultural tile drainage (D. Reid, pers. Comm.). Nutrient input from agriculture is closely related to, and affected by, soil erosion.

The expanse of marshes in the Long Point area likely perform an important assimilative function for the local ecosystem because marsh vegetation slows the eutrophication process by absorbing or inactivating nutrients (Bayly 1979).

Agency Activities: Eight agencies involving all levels of government have enforcement, management, or planning functions related to this stress.

Phosphorus control was one of the cornerstones of the 1972 and 1978 Canada-United States Great Lakes Water Quality Agreement. In 1976 the IJC recommended to governments that a phosphorus limitation of 1 mg/l be accepted for municipal sewage treatment facilities with a capacity larger than about 4.5 million litres per day in the Great Lakes; in 1982 the IJC recommended that this be set at 0.5 mg/l for the lower Lakes (IJC 1982). In November 1983 targets for reductions in the total phosphorus loads entering the Lakes were reached under the terms of the Great Lakes Water Quality Agreement (IJC 1983).

The Ontario Ministry of the Environment (OMOE) enforced the installation of phosphorus-removal equipment in sewage treatment plants on Lake Erie and Lake Ontario. Consequently, the main sewage treatment facilities in the Long Point area all now discharge effluent containing less than 1 mg/l of phosphorus (IJC Water Quality Board 1980).

Through their Great Lakes Biolimnology Laboratory, the Federal Department of the Environment conducts research and surveillance projects under the Great Lakes International Surveillance Program (GLISP). The Department of the Environment (DOE) also administers the Canada Water Act under which phosphorus concentrations in detergents were reduced by 98% in 1970.

In 1978, the OMOE produced a set of regulations which specify a limit on phosphorus levels in effluent. Guidelines closely parallel to those of the 1978 Great Lakes Water Quality Agreement are enforced through the Environmental Protection Act and the Ontario Water Resources Act.

The Ministry also issued Certificates of Approval for Stelco and Texaco sewage treatment facilities. Recently under the Environmental Assessment Act, the Ministry assessed the water supply and the waste treatment requirements of the central part of the Region, including the new town of Townsend and the existing communities of Jarvis and Hagersville. The application of sewage sludge to farm fields also requires approval by OMOE, including a soil nutrient test. This test is to determine whether the soil actually needs fertilizing. The Ministry is responsible for benthos studies, water quality analysis, and phytoplankton studies for the Nanticoke Environmental Committee (NEC).

Formed in early 1968 to undertake base-line studies that would reveal any changes in the aquatic environment resulting from the Nanticoke industrial development, NEC consists of representatives from the three industries (Stelco Inc., Ontario Hydro, and Texaco Canada Inc.) and two government agencies (the OMOE and the OMNR; Weiler 1980). For the first decade, to 1978, responsibility for the programs and funding of the NEC were allocated as follows (Weiler 1980):

Program	Agency Responsible
Temperature	Ontario Hydro
Currents	Ontario Hydro and the OMOE
Water Quality	OMOE
Phytoplankton	OMOE
Zooplankton	OMNR
Benthos	OMOE
Macrophytes	Ontario Hydro
Fish	OMNR

The three industries have funded their own studies and the OMNR's involvement in the program. The OMOE has generally funded all of its own activities.

The Ontario Land Corporation, a provincial Crown corporation closely linked with the Ontario Ministry of Municipal Affairs and Housing (OMMAH), is responsible for planning and coordinating development in the new town, Townsend (Benson 1980). This town is being developed in response to predicted employment increases generated by the recent industrial and associated development in the Nanticoke region. A population of 40,000 people is projected for Townsend by the end of the century; this estimate has been scaled down considerably from earlier predictions which had estimated several thousand inhabitants by 1980 and 250,000 by 2000. The town has been designed to include a storm drainage system entirely separate from the sewage system. The drainage system also contains several retention ponds and a small lake to reduce the flow of sediment into Nanticoke Creek (J. Tonking and B. Wilson, pers. Comm.).

Through the Ontario Farm Productivity Programme, the Ontario Ministry of Agriculture and Food (OMAF) offers cost-sharing with farmers for liquid manure storage systems. There has been a historical tendency for livestock farms in the area to concentrate operations (i.e., changing from pasture to feedlots). Consequently, there has been a concentration of animal wastes which are difficult to manage and occasionally get into local streams. The OMAF subsidy is partly intended to reduce this problem. This program also assists farmers with capital costs of soil management and erosion control (G. Driver, pers. Comm.; IJC/PLUARG 1980).

The Regional Municipality of Haldimand-Norfolk has responsibility for sanitary sewers and water services. The Official Plan contains provision for sewage system approvals before they are operational (Part III, Sec. 11.3.2 and Sec. II.3.3), industries to pretreat sewage (Sec. II.3.4.), the establishment of monitoring systems for new developments (11.3.5), the intention to improve existing sewage treatment facilities “where possible” (11.3.7), and sanitary sewage systems (11.3.9). These bylaws reflect the intent of the Ontario Water Resources Act and the Environmental Protection Act (A. McLarty, pers. Comm.).

The Long Point Region Conservation Authority assists with extension programs to reduce erosion and encourage better land-management practices. One of the purposes of these programs is to reduce the input of phosphorus and other nutrients into streams and rivers. The Authority also has equipment to test water for basic nutrients (W. Baskerville, pers. Comm.). A comprehensive watershed management plan was adopted in 1983.

3.3.4 Sediment Loading and Turbidity

Situation: Sediment loads in the study area come primarily from two sources: (1) erosion from the bluff west of Long Point and sediment loading to streams from natural erosion; and (2) land-based human activities. Sediment has been eroded from the shoreline bluffs and swept eastward by longshore currents for thousands of years. It has been estimated that about 20 million tons of fine-grained sediment (silt and clay, but not including sand) are annually eroded off the bluffs between Rondeau and Long Point (Hamley and MacLean 1979).

Natural erosion also occurs on inland rivers and streams as a result of weathering and floods. A less natural but equally serious form of erosion is human-induced. Farming has expanded to river and stream banks throughout much of the region. Drainage ditches run alongside fields of tobacco, cereals, vegetables, and pasture. Agricultural practices such as monocropping, removing hedgerows that break the wind, and removing trees and shrubs that normally buffer streams from the forces of erosion have rendered thousands of hectares of land in the study area susceptible to soil erosion. Farmers cannot be blamed for maximizing production in an era of diminishing net incomes; but some of these land-use practices also result in tons of soil being eroded away by wind and water into drains and streams which eventually feed into Long Point Bay. Sediment contained in runoff from urban areas, particularly those under construction, is also a problem throughout the Great Lakes basin (IJC/PLUARG 1980).

Much of the eroded material is laden with nutrients such as phosphorus and various microcontaminants which bind to the soil particles. These particles eventually end up in lake sediment where some of the nutrients and contaminants are released to be absorbed into the food chain. Sediment containing such contaminants is easily resuspended by natural currents, storms, and mechanical forces such as boat traffic. The sediment of the Inner Bay is presently being studied to assess its possible contamination with organochlorine pesticide residues (A. McLarty, pers. Comm.).

Sediment loading also adversely affects aquatic biota. Rock and gravel substrates necessary for fish as spawning sites are frequently covered by sediment. Highly turbid water also reduces primary productivity in the phototrophic zone by interfering with light penetration, as well as hampering the vision of fish predators.

Agency Activities: Agencies involved in reducing the input of inorganic particulates or controlling erosion include the IJC, OMNR, OMAF, OMMAH, The Regional Municipality of Haldimand-Norfolk (Region), and the Long Point Region Conservation Authority (LPRCA).

The IJC report on pollution from land-use activities (IJC/PLUARG 1980) emphasizes nonpoint source pollution, and recommends measures to curb its impacts and magnitude. The PLUARG report is known to most agency representatives interviewed, and seems to be influencing agency programs (Switzer-Howse 1982; IJC/SAB 1983).

The OMNR has annually spent $500,000 under the Strategic Plan for Ontario Fisheries (SPOF) in recent years throughout the province on stream- and fishery-related rehabilitation programs (N. Smith, pers. Comm.). Ministry programs of rehabilitation fall into three basic categories: extending assistance, advice, and labor to landowners; education through various media; and influence and control over land-use policy.

Extension projects in the Long Point area include mainly stream bank and gully erosion control projects which the OMNR funds in part through SPOF. In the Long Point area, these projects are shared with the LPRCA, who often provide the labor, and with OMAF. A Ministry biologist or someone on contract usually does the extension work with landowners.

Education programs are many and varied. Staff of the Simcoe office have written articles in local farming magazines such as *The Canadian Tobacco* Grower, explaining the values of erosion protection measures to farmers. The SPOF money was used to fund 50% of the television program shown on T.V. Ontario called "Sport Fishing," which included various messages about conserving fish habitat and conservation practices. Also, the Aylmer District Office (OMNR) produced a film entitled "Coldwater streams: endangered habitat," which carried strong conservation messages (N. Smith, pers. Comm.).

The OMNR had recommended that cold-water streams be designated as "environmentally sensitive areas" in the Official Plan of the Regional Municipality. This would have meant that farmers wishing to install a drain to one of these streams would require an environmental review of their project before it could be approved. Although the Region originally accepted this designation, strong opposition from the Townships forced the Region to exempt cold-water streams from the environmental review process, requiring instead consultation with the appropriate agencies (C. Selby, pers. Comm.).

Hazard lands were designated by the OMNR throughout much of Ontario. The Region uses both the OMNR designations and the Conservation Authority flood and fill lines in zoning lands as "hazard," and preventing "incompatible" development.

About 27% of the 32,000 ha of woodlands in the OMNR's Simcoe District is under forest management. Public Forests are managed as Forestry Agreement Areas by the OMNR and agreements to manage some privately owned woodlands have been made through the Woodland Improvement Act (OMNR 1983).

In response to the clearing of hedgerows, levelling of land, cropping to the edge of drains and stream banks, inadequate construction of drains, and erosioninducing tillage practices, OMAF has a variety of programs and policies intended to mitigate or control erosion. These programs include research, education, extension, and incentives, all of which are offered to farmers through recommendations or advice. In 1978 and 1980 OMAF organized conferences on farming in which the central themes were farming practices and erosion control. Sound agricultural practices involving tillage and soil conservation were emphasized. Locally, through the Ontario Soil and Crop Improvement Association, meetings and field days for local farmers are held in which the same messages are conveyed, emphasizing the economic benefits of erosion control (G. Driver, pers. Comm.). For instance, in January 198 1 the Simcoe District of OMAF held a mini-conference for local farmers on soil productivity maintenance in which a central theme was erosion control (N. Richards, pers. Comm.). Extension programs are implemented at the watershed level by Conservation Authorities. OMAF provides planning assistance as well as assistance in dealing with farmers (the District Agricultural Engineer),

The OMAF provides financial incentives to farmers to enhance conservation and production. Through the Farm Productivity Incentive Program, costs are shared for certain types of capital expenditures such as liquid manure storage systems and erosion control measures. Over 10% of all OMAF money spent on erosion control in Ontario was spent in Norfolk County (N. Richards, pers. Comm.). The Ministry also funds, at $2.2 million per year, a province-wide incentive program administered by the Municipalities to encourage tile drainage. This incentive, intended to expand productive agricultural land, subsidizes interest rates on loans for tile drainage to 6% per year, repayable over 10 years. An OMAF spokesperson does not consider tile drainage as significantly affecting the water table, nor encouraging erosion (G. Driver, pers. Comm.). In 1983 OMAF initiated The Ontario Soil Conservation and Environmental Protection Assistance Program to provide technical and financial assistance to farmers for rehabilitating eroding farmlands. Several individuals in the Region have already participated in this program.

The Ontario Land Corporation is responsible for the planning and development of the new town of Townsend. As urban runoff is often a significant contributor of sediment and contaminants to estuaries, it is important that measures be taken to reduce urban runoff or at least control its impact on the lake ecosystem. Such measures are incorporated into Townsend's design in the form of separate sanitary sewage and storm drainage systems. The storm drainage is a system of ponds and a small artificial lake that slow flows and consequently settles out much of the sediment before it reaches Nanticoke Creek (J. Tonking and B. Wilson, pers. Comm.).

Other erosion controls were incorporated into the construction process. For example, the entire installation of the Town's service infrastructure (for 40,000) was accomplished in summer 1980. This was considered a major achievement because the amount of soil eroded away is strongly dependent on the length of time that a site is being worked over. Riprap and straw bales were also used to control stream bank erosion during construction.

In response to erosion problems, LPRCA has several programs including education, extension, advice, and planning. Education programs involve displays or demonstrations of conservation practices used by the LPRCA. For example, in 1980 it had a major exhibit and demonstration at the Oxford Plowing Match, as did OMAF and other interest groups (LPRCA, Annual Report 1980).

Influenced by the PLUARG work, the Authority has developed land extension programs. The 1980 Annual Report discusses “developing a good working relationship” with OMAF. LPRCA General Superintendents have assisted OMAF Agricultural Engineers in erosion control techniques. Examples of extension work include eight erosion control demonstration projects that were completed in 1979. These projects were funded jointly by the OMNR, the LPRCA, and the landowner, and designed largely by the OMNR while the LPRCA provided labor. In 1979, the LPRCA spent about $50,000 on these projects (LPRCA, Annual Report 1980).

The Authority also reviews and advises on development and land-use proposals as they relate to questions of soil stability such as erosion. The Authority’s comprehensive watershed management plan, adopted in 1983, includes provisions for inventorying and identifying problems in the watershed, and for programs in response to them. Finally, the Conservation Authority acquires land as it becomes available. For example, in 1979 the LPRCA, in conjunction with the OMNR and the Richard and Jean Ivey Foundation, purchased about 25 ha of “distinctive natural muck environment to maintain its water holding and recharge abilities as well as preserving and enhancing wildlife habitat” (LPRCA, Annual Report 1980).

3.3.5 Stream Modification: Dams, Channelization, Logging, and Changes in Land Use

Situation: In the Long Point area, various types of dams and extensive land clearing have affected the aquatic ecosystem in several ways.

Dams prevent fish from migrating to their spawning grounds, change the natural flow rate in rivers, prevent the flushing process of spring floods, and increase water temperature. Seven dams are on the main channels of Big and Dedrick Creeks. Some dams in the area no longer serve their original purpose (such as the Delhi dam) but are maintained for other reasons by the Conservation Authority.

Many farms, particularly tobacco farms, require extensive irrigation; consequently, many construct private dams to facilitate irrigation. Dams on these irrigation systems can interrupt fish migration as well.

In Haldimand-Norfolk, the soils are generally unconsolidated, sandy, and well-drained to the west and compacted clays to the east. Slow-moving warmwater streams occur to the east, whereas streams to the west are generally cold, fast, and have carved deep ravines into the landscape. Many of the cold-water streams have been historically protected from encroachment by their steep, forested banks which are too hazardous to farm or build on. One manifestation of clearing land to the ravine edge is the slumping of vegetation along the stream banks.

Agency Activities: As one of the manifestations of this stress is sediment loading, many of the agency programs are the same as for the previous stress.

For this reason, the programs will only be mentioned briefly. The OMOE, OMNR, OMAF, Region, and the LPRCA all have real and potentially important roles in reducing this stress.

The Environmental Assessment Act is the main OMOE tool for planning and ensuring that environmental concerns are incorporated in any environment-modifying projects. The only Environmental Assessment in the Region thus far concerns the water and sewage servicing needs of the Nanticoke and Townsend developments.

Through SPOF, the OMNR funds or partially funds programs such as bank stabilization or habitat reconstruction, usually carried out by the LPRCA (see under LPRCA) but supervised by Ministry staff (N. Smith, pers. Comm.). Through the Lakes and Rivers Improvement Act, any irrigation plan or drainage scheme requires review by OMNR. The Ministry is generally opposed to dam construction, especially on cold-water streams (N. Smith, pers. Comm.). Farmers who build stop-log dams for irrigation are encouraged by the OMNR to operate them only when they require water (July, August) to permit fish migration to and from upstream spawning grounds.

Currently the OMNR is considering dam removals on several area creeks (D. Reid and N. Smith, pers. Comm.), and have also engaged in habitat restoration where it has been deemed necessary. In one instance it was reported the OMNR used the Fisheries Act to ensure that restoration measures were undertaken on Young Creek, a cold-water stream, after a Township road construction crew had cut through a meander to take a shortcut. After the OMNR threatened to lay charges, a Township work crew graded the slope, riprapped the banks, and created a spawning bed in the process of restoration. Field Inspectors of the OMNR are involved in reviewing construction plans and development proposals. However, the problems generally result during construction whenever contractors tend to cut comers to save money (N. Smith, pers. Comm.).

Many OMAF programs were discussed above under the heading of “sedimentation.” Drainage systems are encouraged under the Drainage Act and the Tile Drain Act. Agricultural land is lost to urban and industry-related uses. For example, 4,000 ha, much of which is considered good agricultural land, was appropriated by the Stelco-Texaco-Hydro installations and the accompanying industrial park. A consequence of disappearing agricultural land and expanding urban and industrial developments is the squeezing of remaining natural areas by competing land uses.

The LPRCA maintains nine dams within its watershed (LPRCA, Annual Report 1980). It is presently considering plans for the construction of a large dam and reservoir on Otter Creek. The main purpose of this reservoir would be to supply drinking water to the Town of Tillsonburg.

Stream improvement projects carried out by the LPRCA staff are directed by the OMNR District Biologist and funded by SPOF. Projects were carried out on many cold streams to reduce erosion and silt loads. The main purpose of such projects is to improve habitat for resident and spawning trout and other cold-water species; the LPRCA also purchases land to protect it from environmentally destructive uses.

3.3.6 Dredging and Sand and Gravel Extraction

Situation: In the Long Point area, dredging and natural gas extraction are the main stressful activities in this category.

These activities cause problems due to the resuspension of sediment and the spreading of sediment over a wide area. A direct consequence of these activities is the covering and/or loss of gravel and rock spawning reefs. The major port at Port Dover, as well as other ports in Dunnville, Port Rowan, Port Maitland, and Nanticoke, are all dredged periodically to keep navigation channels open. Other channels in the marshlands, used by fishermen, hunters, and boaters, are also dredged.

Major dredging and channel construction work was required for the construction of Stelco's docking facility. This entailed considerable blasting into rock substrate to deepen the channel for large ships.

In addition to these dredging and construction activities, the whole of Long Point Bay is a matrix of natural gas pipelines tapping into hundreds of wells. These wells are an important source of valuable natural gas, but also pose potential problems, mainly involved with their installation. Fishermen report some damage to fishing gear that gets caught on these structures (Val and Nelson 1983).

Agency Activities: Any dumping of fill or excavation of materials from the bed of navigable water requires an approval from the Federal Department of Transport (DOT) under the Navigable Waters Protection Act. The DOT circulates dredging applications to other Federal and Provincial ministries for review. The Department of Public Works plans and designs dredging projects in ports with navigable waters under the Public Works Act. The average annual quantities of dredge spoils removed in years before 1975 (in thousands of cubic meters) were Nanticoke, 64.6; Port Dover, 6.4; Port Rowan, 1.5 (International Working Group 1975). However, the "present functional organization and administration arrangements of government agencies tends to place responsibility for the protection of the environment with regulatory agencies which are different from the executing agencies usually concerned with the planning and design projects" (International Working Group 1975). No problems with contaminated dredge spoils in the Long Point area were reported in the interviews with agency representatives.

The OMOE, through the Ontario Water Resources Act (OWRA), requires that dredged material be disposed so that it does not pollute the water. This is done mainly by advising the applicant of water quality requirements and the terms of the OWRA.

The disposal of dredge spoils from the construction of the Stelco dock required OMOE approval. Spoils were disposed of about 4 km off the end of the dock at an approximate depth of 10 m (Wilkins and Persuad 1976). An OMOE study determined that the spoils were relatively stable in the containment area although the water depth was not sufficient to prevent resuspension of silt and clay-sized particles. Mudpuppies were found in sediment at a study station near the dock facility during two years (Wilkins and Persuad 1976); they indicate a fairly healthy environment at the lake bottom.

Natural gas drilling poses other concerns. Fraction fluids containing oils, acids, and various chemicals are used in getting the wells into production. They invariably find their way into the environment (Wilkins and Persuad 1976). However, no prosecutions have been made and this is not considered a serious pollution problem.

One of the problems anticipated with the Stelco dock was the effect of dynamite blasts on nearby fish populations. The OMNR conducted Stelco-funded tests on the impacts of preconstruction and construction blasting. Blasting proved to have a less severe impact on fish populations than was anticipated (Teleki and Chamberlain 1978).

The OMNR also administers the Petroleum Resources Act, under which it is responsible for regulating the natural gas drilling activity in the study area. The OMNR has six inspectors or Petroleum Resource Officers, as well as summer students who supervise all drilling activity on the Canadian portion of the Great Lakes. The Supervisors are mainly concerned with safety on drilling rigs, although environmental considerations are of secondary concern (R. Hayward, pers. Comm.). Environmental protection precautions taken on rigs include sewage disposal systems, which keep the solids on board, and an entirely closed system for the fraction fluids. Problems associated with the network of wells and pipes have involved ships dragging anchors across well bulkheads or pipelines and causing spills. Such spills create little if any environmental concern because the volume of oil or gas is usually small (R. Hayward, pers. Comm.).

The LPRCA, under the Conservation Authority Act, can determine the placing or removing of fill of any kind within any watershed area in its jurisdiction. The LPRCA dredges channels only on their existing properties (Lee Brown Marsh) to maintain them. Dredge spoils are disposed of on the banks bordering the marsh. Spoils are analyzed by Ducks Unlimited, who have a considerable interest in the marsh (W. Baskerville, pers. Comm.).

3.3.7 Filling, Shoreline Structure, Offshore Structure

Situation: Shoreline and offshore structures alter long shore current movements. This can result in increased erosion in some areas, increased sedimentation in others, and a generally disrupted hydrodynamic environment. Altered currents produce different effects on land masses, sand spits, and similar formations, altering the habitat and species composition of the ecosystem.

The Long Point area is affected in this manner by major docks and smaller, often private structures installed to prevent erosion. Much of the shoreline on the western part of the area is composed of sand and glacial tills which form high bluffs above Lake Erie in parts of the Central and Western basins. Average annual erosion rates of up to 5 m have been recorded on parts of the shoreline in Elgin County (Environment Canada and OMNR 1975). Erosion occurs at an accelerated rate during periods of storms and floods. In response to this loss of land, people have advocated and installed various structural solutions in an attempt to halt erosion from this dynamic process (Kreutzwiser 1979). This generally takes the form of groynes, jetties, and dykes which are intended to interrupt the force of current and wave energy. The predominant long shore current movement on the Lake Erie north shore is southwest to northeast, the direction of the prevailing winds. Consequently, structures such as those discussed alter the natural dynamic to their north-east.

Landowners between Port Burwell and Long Point have sued the Federal Government for what they believed to be accelerated loss of their property on the shoreline because of the Port Burwell dock which extends several kilometers into Lake Erie. The major docking facilities constructed at Port But-well and at Nanticoke (by Stelco) have also altered the hydrodynamics. While the Stelco dock was being constructed, cottage owners to the west were upset about their beaches being eroded away while owners on the other side smiled as their beaches expanded before their eyes (A. McLarty, pers. Comm.).

Agency Activities: Kreutzwiser (1979) pointed out the highly fragmented nature of government institutional arrangements in response to shoreline erosion and flood damage. "There are," he states, "at least nine federal and nine provincial agencies as well as the IJC involved in Lake Erie shoreline flooding and erosion" policy. The Regional Municipality of Haldimand-Norfolk is also involved through the lakeshore policy provisions in the official plan.

A number of agencies share costs or provide subsidies through various assistance programs which modify the hazard or provide various forms of emergency assistance. These agencies include the Federal departments of the Environment, Public Works, Emergency Planning Canada, Central Mortgage and Housing Corporation, and the Ontario Ministries of Natural Resources, Agriculture and Food, and Treasury and Economics.

Studies have been under way since the mid- 1960s for regulating Great Lake levels to reduce flood hazards, lengthen the shipping season, and maintain hydropower production. However, to date, no schemes addressed by these studies have been implemented.

The DOT issues permits through the Navigable Water Protection Act for the construction of navigational and shore protection works along the north shore of Lake Erie (Kreutzwiser 1979). The Departments of Environment and Fisheries and Oceans conducted the Great Lakes Shore Damage survey in the early to mid-1970's, in which hazardous areas were mapped (Environment Canada and Ontario Ministry of Natural Resources 1975). The DOE also issues weather warnings in advance of expected floods.

The Stelco dock structure required approval by OMOE. In response to OMOE and OMNR concerns about the dock adversely affecting fish migration and creating erosion problems on the shoreline, Stelco proposed a 1.2-km dock designed to permit current flow under bridged parts of it. A 332-m bridge links a 422-m rock-filled causeway with the mainland, allowing long-shore currents to pass under the bridge. Construction of this structure cost Stelco an additional $12 million more than a normally constructed dock (A. McLarty, pers. Comm.). Since completion, the design of the dock has produced the desired results and has not adversely affected the surrounding environment. As a bonus, the rocks and boulders used in causeway construction could provide potential fish spawning habitat.

The OMNR requires a permit under the Lakes and Rivers Improvement Act for shoreline alterations. The Ministry is also responsible for hazard land mapping in the study area, which was incorporated into the land-use policies in the Official Plan of the Region.

The Regional Municipality of Haldimand-Norfolk has a Lakeshore Policy Area which amounts to a special land-use planning area in the Official Plan. Subsequently, the Lakeshore Policy Area has the following principles:

> "7.2.2. New development should locate in areas which are not susceptible to environmental hazards such as erosion;
> 7.2.3. The natural environment of the lakeshore should be protected and improved."

These principles translate into several policies which direct and regulate areas and types of development within the regional boundaries (Sect. 7.3.2-7.3.23). The most important of these bylaws in regard to this stress include designation of a recession zone corresponding to the Canada/Ontario Great Lakes Flood and Erosion Area Mapping in which limited uses are permitted (7.3.14). These policies include stipulations on the type of construction which can occur in a recession zone. The municipality is also required to consider alternatives such as relocation when municipal roads are damaged. Detailed studies of the impact of proposed private erosion control structures on adjacent shorelines are required before approval is given for grants under the Shoreline Assistance Program (Regional Municipality of Haldimand-Norfolk 1980).

3.3.8 Major Degradative Incidents

Situation: The region has potential for oil spills, gas line ruptures, and toxic waste chemical spills due to the nature of industrial and resource development in the area. The only incident in recent years of significant impact was an oil spill in Long Point Bay in December 1976. About 3,900 ducks, of which 97% were oldsquaw, were killed.

Agency Activities: The OMOE is the lead agency in planning and managing a major cleanup or responding to a catastrophe. Through the Ontario Contingency Plan, a variety of other agencies are involved. This plan is legally binding and provides the OMOE with considerable authority and power to deal with a situation. Regional plans exist in which the OMOE is also the lead agency. These plans respond to less severe problems which can be dealt with on a local basis (A. McLarty, pers. Comm.).

3.3.9 Conclusions

Table 3.13 summarizes the main program activities of agencies in the Long Point area with reference to these eight categories of ecosystem stress. From this review of agency programs, a clearer picture of responsibility and role emerges. Most agencies acknowledge, in their programs, an awareness of the sensitivity of the ecosystems in the Long Point Bay area and show a commitment to ecosystem maintenance and restoration. However, these policies and programs are balanced against other interests and goals such as economic development.

The general impression is one of many agencies doing several things for

Table 3.13 Summary of agency activities relating to eight ecosystem stresses in the Long Point area.

	Cultural stresses on the ecosystem							
Agencies	Fishing	Other recreation	Nutrient control	Sediment control	Stream modification	Dredging	Shoreline modification	Major degradative incidents
International Joint Commission			S	S		S	S	
Great Lakes Fishery Commission	S							
Department of Environment			S				S	
Canadian Wildlife Service	E	E/M						
Department of Transport						E	E	
Department of Public Works						E	S	
Ministry of Natural Resources	E	E/M	S	S	E/M	E	E/S	
Ministry of the Environment			E/M/S		S	E	E/S	M
Ministry of Agriculture and Food								
Ministry of Municipal Affairs and Housing			MIS	s	S		S	
Regional Municipality of Haldimand-Norfolk			E / M	E / S	E/S		E/M	M
Long Point Region Conservation Authority		E/M	S	E/M	E/M	E		

Activities: E, enforcement of regulation; M, direct management; S, other supporting activities, including funding work of other organizations and coordinating roles

many reasons. Although some agencies such as OMNR have an important role in rehabilitation for most stresses, the picture is largely one of fragmentation of responsibility and activity. Consequently, overall themes and conclusions are difficult to reach except with reference to individual stresses.

Some questions, such as who actually makes trade-offs of, for example, environmental quality versus economic gain, private versus public rights, or the relative reliance by government on non-policing versus policing agencies, arise in programs relating to several stresses. Examples are indicated in the discussions for shoreline protective works, and runoff from agricultural lands.

Perhaps the only overall conclusion to be reached is that district-level workers have little time and fewer funds to consider their work in a larger perspective such as ecosystem rehabilitation. Budgetary cutbacks and freezes have only accentuated this. If a means could be found to introduce a larger perspective and have it incorporated into institutional arrangements, it would at least provide a forum where communication could be improved, gaps in programs and policy could be gradually filled, and the fragmented parts of the many program activities could be brought together in a more coherent manner. It is also important to ask whether the present mix of subsidies, regulations, etc., could be improved upon. Questions concerning these and other policy instruments are addressed below.

3.4 Policy Instruments for Managing the Long Point Ecosystem

Although the Long Point ecosystem has been maintained at a higher level of quality than any other part of Lake Erie, it is vulnerable to damages from accidental oil spills, agricultural runoff, increased or intensified recreational uses, and other human activities associated with industrial growth centered in the nearby Nanticoke area. Hence, the Long Point area requires continuing protection rather than extensive rehabilitation. Which policy mechanisms would enhance such protection?

3.4.1 Allocation of Rights to Use Resources

The basic challenge that faces environmental policy-makers is how to influence the behavior of producers and consumers of goods and services so that they would not pass on or externalize some of the costs of their activities to others. For example, an industrial plant may pass untreated effluents into the ambient air or water to reduce its costs of treatment. No price is paid for this service by the industry, even though other more sensitive uses (e.g., wildlife and recreation) may be affected.

Dales (1975) has argued that elements or features of the natural environment and its resources are not themselves allocated to individuals or groups in society, but rather that certain rights to use some aspects of these elements may be so allocated. The formal marketplace is only a particular kind of allocative device. To facilitate a broader analysis of allocative devices, Dales proposed a two-dimensional classification of rights, i.e., as to whether they are *exclusive* or *not exclusive* and whether they are *transferable* or *not transferable.* Both qualities may be viewed as dichotomies (as preferred by Dales) or as the extremes on continuous scales (as preferred by us).

In Fig. 3.1 we elaborate some allocative devices and in Table 3.14 we identify 12 allocative mechanisms based on the terms on the left side of Fig. 3.1; these mechanisms describe a spectrum from top to bottom. Generally speaking, allocative mechanisms which are specifically exclusive (and opposed to patronage and common ownership) are more congruent with current emphases on property rights and explicit permissions to use.

The eight clusters of terms set in Figure 3.1 serve to identify and characterize very briefly the various allocative alternatives (or non-allocative alternatives as in the two clusters farthest to the right). Most may be recognized as operating currently to some degree with respect to various ecosystem components and their many valued features in the Long Point area. The non-allocative device at the bottom right hand comer involves ignorance, misconceptions, falsehoods, and fraud and is a “pathological,” illegal, or irrational domain. It is included here not just for the purpose of symmetry in the figure, but also because society needs to get involved in corrective action in these kinds of situations.

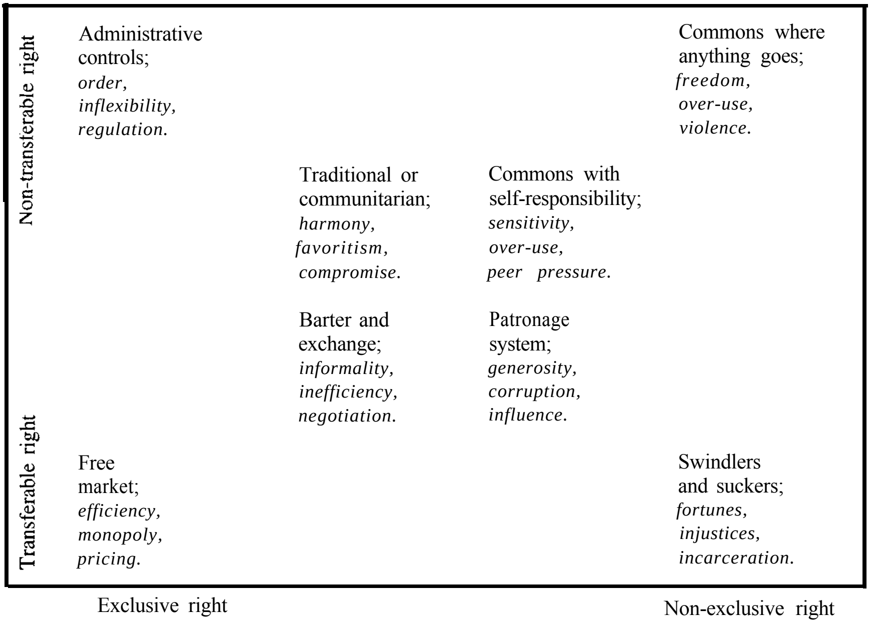

Figure 3.1 A perspective on the nature of allocative devices to the rights to the use of the natural environment and renewable resources - exclusive vs. non-exclusive, transferable vs. non-transferable. The first and second italicised terms are commonly recognized (though not inevitable) desirable and undesirable features, respectively of each of these regimes; the third term identifies a process or mechanism associated with each.

Regier and Grima (1984) proposed that the four outer comers constitute a more formal, more sharply defined set or "hard shell," whereas the inner four elements constitute a less sharply defined and less formal "soft core."

Regier and Baskerville (1985) have examined briefly the relationship of Fig. 3.1 to the needs of internal (local) and external (regional, provincial, etc.) decision-makers with respect to use of the natural environment and renewable resources of an ecosystem like that of Long Point. Formal "hard shell" allocative processes may predominate with respect to external interests, say those centered in a metropolis, and informal "soft core" processes may predominate with respect to interests of people residing within the ecosystem or within the hinterland as a relative term.

Table 3.14. Institutional or Policy Mechanisms for Allocating Natural Resources

1. Prohibition, e.g., commercial harvest of sport fish, dumping of toxics or contaminants into the ecosystem.
2. Regulation, e.g., phosphorus concentration in sewage effluents to reduce eutrophication, control of commercial fishing intensity on preferred species so as to prevent over-fishing and collapse of fish stocks.
3. Direct government intervention in the ecosystem, e.g. in sea lamprey control to foster the recovery of lake trout, development of islands and headlands in appropriate places with fill and dredge spoils to increase the availability of spawning areas or reduce wave action.
4. Grants and tax incentives, e.g., a subsidy to industry for anti-pollution equipment, a subsidy to commercial fishermen to harvest relatively undesirable species to the advantage of users of preferred species.
5. Buy-back programs, e.g., government purchase of excess harvesting capacity in fisheries which is then retired in order to reduce effective fishing capacity.
6. Liability for compensation, e.g., losers of an amenity have the right to sue the despoilers of that amenity.
7. Compulsory insurance to compensate victims of pollution damage.
8. Effluent charges, e.g., a charge for waste disposal scaled according to the direct cost of the disposal or to the indirect cost associated with deleterious impacts on a receiving ecosystem; effluent charges may be incorporated into delayed pollution control charges.
9. Resource rent, e.g., royalty tax or charge on harvesters of a resource in order to recover a fair return for the owners (all the people) of the resource, and also to foster efficient use of the resource by discouraging overcapitalization.
10. Management of the demand, e.g., through rate structures involving marginal cost pricing and/or peak responsibility pricing to improve overall efficiency of use and foster conservation.
11. Transferable development rights, e.g., limited rights to develop a particular area may be exchanged for broader rights to develop a different area as preferred by government.
12. Transferable individual quotas, e.g., "assimilative capacity" rights in the case of pollutants, harvest rights to explicit quantities in the case of natural resources.

The kind of information particularly appropriate to more informal, internal decision-making may be quite different from that appropriate to more formal, extended decision-making. That the scientific approaches are somewhat different has long been recognized, but we are only now beginning critical study of the differences in scientific approach.

Our approach in this prospectus is to help the development of the less formal, internal information, planning, and decision process with the end of assisting committed husbandmen of the locale in their efforts to preserve and conserve the Long Point ecosystem.

3.4.2 Historic Sequence and Current Situation

Figure 3.1 may be used to elucidate a historic progression in the manner in which rights to use a particular feature of the ecosystem have been allocated. Some thousands of years ago, when very few native Indians lived in the area, the natural resources were treated as common property, perhaps a "soft" commons. Eventually, an interactive set of less formal allocative devices was developed, which may have involved territorial, religious, ethical, and economic constraints on overuse and abuse. When the Europeans arrived, the allocative system shifted to that of the "hard" commons, i.e., there was again no allocative process at the level of the social group and the resources were open to abuse by those members of society who did not practice good husbandry.

The European settlers in part also practiced a patronage system, which resembled in some ways the aristocratic devices with respect to the land, fish, and game of their native Europe, although this was similar to the system many of them so roundly detested. But there was also a shift to the administrative devices, now pejoratively known as the bureaucratic system. Gradually the formal administrative system became the predominant device for controlling the overuse of resources, at least with respect to large commercialized resources. Many people have come to feel that this trend toward bureaucratic regulation has gone too far, and are calling for deregulation, but their political leaders have not specified clearly in which direction the system is supposed to devolve. From a local perspective, decision-making at all levels is highly fragmented. The formal marketplace is currently favored for some fisheries in Ontario. However, in Lake Erie the commercial fishermen have favored more self-policing over conventional regulations (Berkes et al. 1983). A traditional approach may be re-emerging in some native (and some angler) fisheries. Some may revert to the commons. During a period of turbulent transitions, a few politicians may seek quietly to expand vestiges of the patronage system. And one should not rule out the occasional illegal transaction akin to swindling and fraud.

Figure 3.1 may also be helpful as a classificatory system for identifying the major allocative device, or the particular combination of devices, that may currently be in use with respect to different features of the Long Point ecosystem. There appears to be no overall rhyme nor reason for the biases or emphases in the overall mix of allocative devices now in place with respect to the natural environment and renewable resources of the area. There are, however, some discernible patterns.

Over the last two decades resource and environmental management has progressively become dominated by rules and regulations. For example, industry may be required to adopt the best available or most practicable technology to meet effluent standards that, in turn, would satisfy broadly defined ambient standards for environmental protection. Fishermen are regulated in terms of season, area, gear, species, and size of fish taken. Farmers, developers, natural gas well owners, cottage owners, hikers, campers, and hunters are all subject to rules, some of which were outlined in section 3.3 above. By and large, protecting environmental quality has been approached in terms of technology-related command-and-control policies. The regulatory approach is so dominant and so pervasive that it has come under increasing scrutiny by politicians (see, for example, Economic Council of Canada 1979 and 1981). Circumstantial evidence exists that as of 1985 there is a consensus that society has gone too far with allocative devices in the upper left comer of Fig. 3.1. Some observers are sensing that an overemphasis on this device tends to entrain a "hard" commons for those resources not yet being regulated and may predispose to an increase in activities designed to circumvent the regulations. There is a trend toward the market system which is in part self-regulated. Unfortunately, the market system tends to reinforce any inequities brought about and reflected in social stratification.

3.4.3 Regulation: A Critique

Some basic criteria for evaluating policy instruments such as those noted above are allocative efficiency, distributive equity, effectiveness, political acceptabilty, and ease of administration. Table 3.15 expands on these basic criteria and is based on the theoretical evaluations in the literature (e.g., Baumol and Oates 1979).

Regulation scores low on nearly every criterion in Table 3.15. The general acceptability of regulations (in spite of their low effectiveness, high cost, and allocative inefficiency) stems from a perception of their fairness and the sense of control that regulations provide to administrators, at least on paper. However, there is often little political will to enforce regulations: they appear to be very harsh but in practice may have little bite. As noted above, industry is typically required to adopt the best available or best practicable technology in order to meet effluent standards which, in turn, are related to ambient standards for environmental protection. This approach would work very well when the community shares a (correct) perception that the benefits of more control are greater than the cost of more control. On this basis, for example, highly toxic contaminants such as dioxin could be prohibited. Phosphate detergents were regulated to a degree in the 1970's in the Great Lakes Basin because the incremental net benefits were expected to be high. Regulation is particularly attractive where monitoring and enforcement are not costly or difficult. Otherwise it has a number of serious disadvantages.

The process of enforcing regulation is usually slow. When litigation is required, the outcome is uncertain and the process is time-consuming and costly. In Ontario, considerable flexibility is deemed necessary in the enforcement of regulations in order to take into account the circumstances of each source of emission (e.g., the condition of the receiving environmental media, employment impacts that might result from the potential closure of plants). However, this discretion also provides ample opportunities for postponing compliance with regulations or guidelines. For example, Victor et al. (198 1) listed 17 prosecutions against Ontario's pulp and paper companies during 1968-77. The fines were all $2,000 or less with one exception when the fine was $64,000. This record may be interpreted as involving an inadequate incentive for compliance, at least in the pulp and paper industry, a conspicuous target for environmental quality concerns. Enforcing regulations that affect large numbers of smaller businesses such as farmers, or large numbers of individual persons such as recreationists, requires even more judgmental flexibility. For example, the regulatory process for reducing flood damage in the Long Point area has been examined in some detail. The lakeshore regulation policy adopted by the

Table 3.15 A matrix of criteria and policy instruments for water/land/air-quality management (revised from Grima and Griffith 1983).

Criteria	Policy instrument: Regulations	Charges	Subsidies	Transferable discharge permits	Demand management	Moral suasion
Efficient allocation of resources	Low	High	Low	High	High	NR
Minimal disruption of plant operation	- Initial disruption is high →				Minimal with time lag	Very infrequent
Information requirements	High	High	Low	LOW	Medium	Low
Polluter/consumer pays	Yes	Yes	No	Yes	Yes	Yes
Provide a continuing incentive for reducing discharge	No	Yes	No	Yes	Yes	No
Efficacious and effective	Low	High	Low	High	High	High for brief periods
Maintain private choice	No	Yes	No	Yes	Yes	NR
Flexible to accommodate growth in economic activities	Medium	Medium	High	High	High	NR
Easy to police/ monitor	Medium	Medium	Easy	Medium	Easy	NR
Does not make producers non-competitive	← Depends on level of standards, charges, etc. →					
Equitable/fair	Equity to producers and income distribution effects need to be assessed in each application					
Takes into account the elasticity of demand for pollution abatement	NR	High	NR	High	High	NR
Does not trade off its effect to other environmental media	← Potential tradeoffs exist; should be assessed in specific cases →					

NR = not relevant

Regional Municipality of Haldimand-Norfolk in 1976 was directed at controlling development (cottages, winterization of cottages, and residential development) in areas susceptible to flood and erosion hazards, and was in large part a response to the serious flooding and erosion problems during the 1972-75 high water period. Jessen et al. (1983) assessed the effectiveness and efficiency of the policy implementation process; their analysis is based on an examination of the permit approval files for the Turkey Point and Long Point peninsulas. Their conclusions are as follows:

> "The policy was ineffective and inefficient in controlling development in the two peninsulas (during the 1974-78 period). Applications were approved in the majority of cases, despite regulatory prohibition of developments in hazard susceptible areas. There were lengthy decision-making delays, often exceeding one year, and frequent violations of regulatory procedures" (p.92).

It should be noted that most applications involved additions to existing structures and did not create new development.

Further revisions to this policy on lakeshore development were made in the 1978 Regional Official Plan. Under these revisions, the policy regulations were relaxed; Jessen et al. (1983) noted that "there is a strong suggestion that public political pressure, especially at the local level, led to the revisions" which are likely to increase the level of damage due to flooding and erosion. These findings confirm earlier reports on flood damage policies in the study area by Day and Fraser (1979) and Kreutzwiser (1979).

Uniform standards fail to allocate the waste inactivation capabilities ("assimilative capacities") to those industries (or plants) that could make best use of them. Generally speaking, the simplified concept of "assimilative capacity" has no ecological validity; one must recognize that a reduction in environmental quality is often the quid-pro-quo for making use of the environment to enjoy material comforts. When emission standards are expected to apply across a wide range of water bodies and economic regions, account is seldom taken of particular plants which could reduce their emission loads at a low cost. There would seem to be analogous difficulties where fishing regulations tend to increase the costs without decreasing competition. The result is some biological protection and a weak, overcapitalized and somewhat unprofitable fishery; Berkes et al. (1983) have demonstrated this for Port Dover's commercial fishery. It can be noted, however, that recognition is now being given to these problems. Ontario Hydro is to reduce total sulphur dioxide emissions by 43% by 1990 (OMOE 1981) and OMNR has implemented (in January 1984) the use of individual transferable quotas for commercial fishermen.

Information requirements may be particularly high for setting standards that are clearly related to the overall quality of a regional ecosystem or even to the health of animals and humans. Where information and understanding are inadequate, the levels of pollution control are usually established more on the basis of the technology available (see case study below).

Finally, regulations do not provide an incentive to abate pollution levels further, once a required standard is met. "Compliance" takes precedence over a shared responsibility for resolving difficult problems. Other deficiencies are as follows: standards usually refer to average rather than maximum discharge rates but temporary discharges at high rates may still cause acute damage to the ecosystem; enforcement of regulations is difficult due to the lack (and high cost) of adequate monitoring and delays because of the due process that is required in legal preceedings; regulations are notoriously ineffective when applied to non-point emissions (e.g., agricultural runoff); and older user stresses such as agricultural runoff, overfishing, cottaging, or recreation pressures also require the regulation of users who have already acquired rights by virtue of long use and who may therefore be more resistant to political pressures for regulation.

The regulatory process works best when applied to new equipment and new towns, i.e., when negotiations behind the regulations are incorporated into the "approvals" process. This is the situation with the Nanticoke industrial complex in the Long Point vicinity; this industrial development was planned over a number of years and the approvals process has been evaluated by Nelson et al. (1980).

The next section reviews this case study to highlight both the advantages and the potential pitfalls in this process.

3.4.4 Regulation: A Case Study

The Nanticoke industrial complex consists of an integrated iron and steel plant (Stelco) with a capacity of 1.35×10^6 tons, an oil refinery (Texaco) with a capacity of 95,000 barrels/day, and one of the largest coal-powered generating stations in the world having an ultimate capacity of 4,000 MW (Ontario Hydro). A new town, Townsend, is under construction nearby. The "approvals" process is designed to protect ecologically sensitive resources such as spawning habitat, wetlands and marshes, and recreational areas. Traditional economic activities such as fishing, farming, and recreation were expected to be considerably affected by an influx of new industry and an (incorrectly) anticipated rapid population growth in the region of 107,000 to 118,000 by the mid-1980's. The value of the tobacco crop, commercial fishing, and recreational fishing were estimated at 100 million, 1 million, and 3.5 million dollars per year, respectively (Nelson et al. 1980).

Determining whether the environmental regulations have been effective and efficient is difficult for two reasons: goals and objectives are not always defined, much less quantified, and different interest groups will define benefits and costs differently. Nelson et al. (1980) examined four types of evidence in order to determine

> "whether environmental protection measures have been implemented within a reasonable time, at reasonable cost and without undue adverse effects on the resource base and on the pre-existing users and residents of the Nanticoke area" (pp. 15-16).

First, the research and planning evidence. No social or environmental impact assessment was carried out on the Nanticoke industrial complex. However, many technical studies were carried out on plant design and construction. In 1967 the NEC was formed to coordinate studies on water quality and the aquatic environment. NEC includes representatives of the Ontario Ministries of the Environment and Natural Resources and of the three major industries. Another committee, the Nanticoke Environmental Management Program (NEMP) was established in 1975 in order to coordinate air quality studies. Nelson et al. (1980) noted that studies in the 1960's provided evidence of pollution damage to tobacco and other crops from U.S. sources. Nevertheless, farmers or other local interests and the regional government are not represented on NEMP or NEC.

This aspect of the Nanticoke case study exemplifies very well both the weakness and strength of the negotiated approvals process. "Numerous technical studies have . . . been conducted on plant design and construction" and hundreds of recommendations about air and water quality, sensitive land uses, and lakeshore policy have been made (Nelson et al. 1980). No doubt this process has resulted in a project and land-use patterns that are less ecologically destructive than would have been the case without this study-approvals process. For example, one design change to a Stelco dock allowed passage of water and fish along the shore. And this was accomplished with no litigation or undue delay. On the other hand, it was noted above that a very large proportion of recreational and residential developments are approved despite the policy guidelines and that there is still potential for encroachment on high-risk floodplains. In addition, there are a number of potential problems that are being studied further: e.g., rare exceedence of sulphur dioxide emission standards, and fumigation from chimney plumes which can result in high ground-level pollutant concentrations. A comprehensive Regional Official Plan has been developed but "no evidence has been found of comprehensive planning and management of Long Point Bay and inshore waters during this study" (Nelson et al. 1980).

The second type of evidence examined was the institutional arrangements and technology used to achieve environmental protection. The innovative institutional arrangement at Nanticoke is a proposed zoning for a 3-km buffer zone; it has not yet been approved because the affected landowners objected on the grounds of expected lower land values and higher polluting levels (e.g., dustfall). Rather than land-use zoning, other instruments, such as compensation, insurance, land purchase, and liability for damage, could have been more equitable and possibly as effective.

The approvals files were also examined. They show that the entire approvals process took 7.5 years for the Texaco oil refinery and 5.25 years for the water treatment plant for the industrial site and municipality. This type of information requires too much subjective interpretation to be directly useful in answering the questions whether the approvals process took too long or was effective.

Tabulations of 43 interviews revealed, as expected, that the Provincial Government officials and industry representatives have positive responses to adequacy of research, adequacy of equipment and technology, equity, etc. Environmental interests have negative or no-comment responses, whereas Federal and local government responses are almost evenly spread. The comments are probably more significant than the tabulations, e.g., the suggestion that a "one-window arrangement" would have facilitated information flows during the approvals process; the buffer zone was severely criticized by non-government, non-industrial respondents on the basis of lack of equity.

The data on cost estimates deserve comment. The environmental protection costs to Stelco, Texaco, and Hydro totalled $227.8 million (or 11.3% of total project costs), whereas the public (i.e., mainly Provincial but including other levels of government) estimated costs were $93.6 millon. The tentative conclusion drawn by Nelson et al. (1980) was that these costs have not been unreasonable, given the level of protection achieved so far. They also concluded that the environmental regulatory process at Nanticoke has been reasonably efficient and effective but reservations were expressed about the lack of comprehensive planning, particularly about the lack of comprehensive planning for the coastal lands, waters, fish, and other resources of the Long Point Bay area.

A somewhat different conclusion is put in an evaluation carried out by other experts for the Economic Council of Canada Reference on Regulation. The Steel Company of Canada estimated that the manpower requirements for designing and engineering the Nanticoke plant

> "were increased by over 30% and the construction costs by 11%, just to meet the delays and regulated standards entailed in the planning and environmental impact analyses and the subsequent rulings of the regulatory agencies. And the company claims that the operating expenses of this plant will become 8% higher than if less stringent, but equally effective, environmental requirements had prevailed" (Economic Council of Canada 1981, p. 124).

The analysis and conclusions from this study of the negotiated approvals process tend to be tentative rather than conclusive because the objective of the regulatory process is to do one's best in an imperfect world. It is a negotiated process that requires mostly subjective judgement, and it is therefore very difficult to assess. However, the four disadvantages of regulation noted in the previous section apply to the Nanticoke situation too, namely the reliance on discussion and negotiation because of the uncertainty and cost of litigaton; the lack of an efficient allocative process as opposed to the adoption of the best practicable technology; the massive data requirements to link emission standards to environmental damage, and the lack of incentives to use technological advances so as to abate pollution levels further than current standards require.

3.4.5 Complementing Regulation

Partly because so much reliance has been placed on regulations supported by various subsidies and other means of persuasion, most of the alternative devices noted in Table 3.15 have not been extensively tried out. Six of the eight types of alternatives shown in Fig. 3.1 have workable allocative outcomes; the exceptions are the top and bottom right-hand comers. It was already noted that the commons tend to be abused in a society where the right to property is a predominant and overriding cultural feature. Patronage is not a preferred allocative tool because it reduces the widely accepted societal objectives of equality of opportunity, fairness, and the need to recognize merit. The more traditional or community-based self-regulation has much to commend it and works well when it is coupled with quasi-property rights that are recognized and respected in the community. Berkes (1983) gives some examples of self-regulation among fishermen in Lake Erie who have the license to use traps and fixed nets; this license is passed on from father to son and has become a quasi-property right.

Alternatives involving exclusive rights represent a continuum ranging from purely administrative varieties of allocation to purely market-related varieties (Table 3.14). The regulation regime has been critiqued at some length above, both in generic terms and through an illustrative case study of the negotiated approvals process for the Nanticoke industrial complex,

There are, however, four policy instruments that would make more use of the market mechanisms in protecting ecosystems such as the Long Point complex: subsidies, effluent charges, transferable discharge permits, harvest quotas, and demand management through marginal cost pricing or peak responsibility pricing. A brief discussion of each of these four mechanisms follows to complement the summary in Table 3.15. Griffith et al. (1981) provided a recent bibliography on "Alternatives to Regulation."

3.4.6 Subsidies and Grants

This group of fiscal incentives is very attractive to politicians and the public, particularly in instances where no attractive alternatives are available (e.g., a locally dominant industry which is marginally profitable). So even if this mechanism ranks low in terms of allocative efficiency, it is usually preferred in terms of political acceptability. In the Long Point area the flood damage reduction policy has been largely a subsidization policy (Kreutzwiser 1979; Day and Fraser 1979). The control of agricultural runoff is also oriented toward subsidies (see Section 3.3 above).

Perhaps the major drawback with subsidies is that a firm obtaining financial assistance may still incur a financial loss on its investment. Therefore, there is a tendency to put off the decision to accept a subsidy unless the new equipment reduces cost in the production process apart from pollution control.

Subsidies are not likely to meet the criterion of allocative efficiency for two reasons: subsidies are usually directed toward capital expenditures, such equipment or protective work may not be the most economical solution to pollution reduction; and subsidies do nothing to ensure that easy-to-control waste disposal or flood damages are eliminated first and hard-to-control damages are eliminated last.

Subsidies transfer the costs of pollution control or flood control damage from the firm and the consumer to the general taxpayer. In addition, the possibility of subsidies may act as an incentive to put off remedial expenditures.

3.4.7 Effluent Charges, Royalties

This mechanism has been discussed at great length by economists (e.g., Baumol and Oates 1979; Dewees et al. 1975), yet its practical use has been restricted to sewer surcharges (Garai 1977). In theory, the firm would choose to control its discharges (or its harvest) up to the point where the increase in control costs are balanced by the effluent charge (or royalty in catch). This would mean that effluents (or harvests) that are least costly to control (or least profitable) would be reduced first, thus approximating allocative efficiency (i.e., a least cost solution).

This mechanism has two major problems with its implementation and administration. The first is the costly information for setting an optimal level of charges or royalties because the damage imposed on the ecosystem is difficult to measure. For example, the determination of charges would be dependent on the cost of regional or municipal treatment plants or on stream-flow regulation or on other pollution control options. In addition, the effluent loads of one firm may affect the production costs of other firms. These damage and production functions may be nonlinear and there may be synergistic effects. Nelson et al. (1980) and Hamley and MacLean (1979) point out that these potential synergistic or cumulative effects are a matter of concern and monitoring in the Long Point Bay area.

The second major difficulty is the high cost to industry that has to control pollution loads up to the point where the increase in costs is balanced by the effluent charge and to pay the effluent charge beyond that point. This could involve a financial strain on firms and could be paid back to industry on a value-added or an employment basis. Similarly, for commercial fishing, this option would involve taxing an already low-income group.

It is worthwhile to note that the administration of user charges (as opposed to effluent charges) does not face the two difficulties discussed above. An effluent charge is a levy against discharges of wastes into the ambient air, water, or land; a user charge is a fee for collecting and treating effluents. One difference is that for a user charge, the funds are used to recover the costs of treating effluents; this amount of funds is much smaller than the cost imposed under an effluent charge where the polluter is required to pay for all damages imposed on a commonly owned resource. Another difference is that the calculation of a user charge is, relatively speaking, simple. It is the cost of treating effluents. User charges have been extensively implemented in North America as sewerage surcharges.

3.4.8 Transferable Discharge Quotas and Harvest Quotas

This mechanism has an advantage over effluent charges: the uncertainty about the response of industrial firms to effluent charges is removed because the total effluent load (or harvest) is set. The difficulty is the auctioning off or awarding of the total quota among polluters (or harvesters). Dales (I 968) argued convincingly that it would be preferable to decide firmly, as a major political commitment, how much more or less total pollution (or harvest) the community is prepared to accept before allocation is undertaken.

Allocative efficiency is enhanced because the effluent (harvest) quotas would be bought by those firms or individuals who value them most (i.e., those firms that would find pollution control most costly or those which could make most profit out of the harvest quota). As with effluent charges, transferable quotas provide an ongoing incentive to reduce pollution loads or to reduce the costs of harvesting wildlife.

The problems with transferable quotas relate to the initial allocation or sale of quotas, the risk or monopolistic buyers, and the delimitation of the geographical regions.

3.4.9 Demand Management

The previous mechanisms have dealt with the interface between the production process and the environment. However, it is also useful to consider the possibilities for pollution (or harvest) control at the interface between consumption and environment by making the consumer (as opposed to the producer) meet the higher social costs as compared with only the private cost. Pricing structures for municipal water, natural gas, and electricity are ways in which consumer pricing could reduce some of the user stresses on ecosystems. This pricing mechanism works in two complementary ways. First, the higher price at the margin (i.e., for the last few units consumed) reduces the demand for these last few units. Second, if peak responsibility pricing is applied, the peak uses for electricity, water, or natural gas, etc., would be reduced; in turn, the expanded capacity required to meet peak demands would not be built and the peak emissions would also be reduced (Grima 1979).

3.4.10 Summary

With respect to the long-term conservation of desirable ecosystem features and to equitable rights to use by many individuals or groups that live in the area, the generic allocative devices falling to the left of the center of Fig. 3.1 are preferred over those that fall to the right of the center. Whether it is the putatively impersonal forces of the marketplace, the coercive local consensus among users in the traditional or communitarian approaches, or the legally binding decision of the expert district administrator or bureaucrat, all the preferred devices imply powerful constraints on what the individual user or interest group can do legitimately.

We emphasize two points made in this section: First, there is no "best" instrument a priori; each practical decision needs to be informed by local conditions regarding physiography, ecological interactions, economic base, and political context. Second, before changing one allocative mechanism to another, one ought to consider fully the potential trade-offs with respect to admnistrative economy, allocative efficiency, distributive equity, and efficacy.

4. FROM ECOSYSTEM PERSPECTIVE TO ECOSYSTEM MANAGEMENT

4.1 A Reprise: Meshing an Ecosystem Rehabilitation Perspective into the Context of the Long Point Ecosystem

We have been developing this prospectus on the Long Point ecosystem from a systemic perspective and we advocate a systemic approach to its management. In so doing we concur with other informed people now active in the planning and management of Long Point and its environs; these people have participated in a variety of recent planning initiatives that are unmistakably ecosystemic in scope and scale, in motivation, and commitment. Our purpose in developing this prospectus is to serve these ecosystemic initiatives and to help support the colleagues who will join in fostering the further evolution of the ecosystem approach. As concerned academics, we have learned much from our association with planners and managers in the different agencies, as well as from our other academic colleagues. We are now reporting back the further work that we have done with the ideas and information that they, in effect, lent us.

We have recounted some leading themes of the natural history of the Long Point ecosystem and its environs as it was when little affected by humans two centuries ago. We have shown how different human interest groups have used and modified it or have abused and degraded it in some respects, then subsequently how rehabilitative measures were undertaken for some of the degraded features. We have sketched its current state, and view it as a relatively healthy man-nature ecosystem. We endorse the determination we found to maintain it this way. We view with cautious optimism the signs that Lake Erie itself has begun to recover under binational management which is now on balance somewhat more rehabilitative than degradative.

We have suggested ways to organize information in a systems perspective. The stress-response approach links analyses to management. The conceptual framework draws upon several ecological paradigms and can serve as a guide for management-oriented ecological research and monitoring.

We have examined how governance through a complicated hierarchy of agencies, a system rivalling in complexity that of the natural part of this man-nature ecosystem, is currently organized and how it is functioning. We have collated a number of statements on management goals for different components of this system, each with some ecosystemic relevance. We have sought to explicate policies on the allocation of use of ecosystemic features to different interest groups and have critiqued institutional mechanisms that are now in use by governments in the service of management broadly defined.

For us, all of this information and the concepts used to organize the information comes together as an ecosystem approach directed to the planning and management of the Long Point ecosystem and its environs. Our guiding perspective is increasingly shared by others. It is holistic in the sense that our *primary* perception and interpretation of the Long Point ecosystem is one of a man-nature unity that exhibits some degree of integral, self-regulating behavior. It is these systemic attributes that now need more explicit recognition in management and more attention in research.

4.2 On Dealing with Complexity

Complementarity must be sought between holistic understanding and reductionistic analyses. The latter can only serve their necessary and powerful roles when directed toward enhanced understanding of the behavior of systems and the detection of what may be atypical deviations from their "normal" functioning. Analysis in the absence of some systems perspective can too easily become a rather pointless, or even trivial endeavor (Kerr 1982; Rigler 1982).

Complexity connotes complications and complications connote difficulties. From the presumed relative safety of a limited agency mandate, a unidisciplinary knowledge, or a specialized professional role, there seems always a temptation to reject ecosystem perspectives, or the commitment to put them into practice. A man-nature ecosystem such as the Long Point area becomes too complicated to understand and impossible to manage as an integral functioning unit.

We believe this view to be essentially invalid. There is sufficient information to proceed and apply an ecosystem approach. Considerable data have been collected in recent decades and some of these have been interpreted in contexts relevant to the ecosystem approach (e.g., Knight 1983; Whillans 1985). The data are becoming increasingly more accessible to the managers, the public, and the politicians. Appropriate conceptual frameworks are being developed within which data can be summarized, interrelated, and interpreted to good purpose. Hence, any plea that, "We need more data before we can make headway with an ecosystem approach" is now also invalid.

We do need more and better information of a number of types (Regier and Rapport 1983). Any data series that extends backward over many years should be continued unless cogent reasons are marshalled to justify discontinuing the series. Data on long-term or recurring stresses caused by humans are needed to keep such stresses under control and, preferably, to relax them rehabilitatively. Each major user group and its regulatory agency will want information relevant to its demands on the ecosystem. Society for purposes of governance of the ecosystem will need definitive information on the state of health of the integrated unity because self-regulatory processes are invaluable and simply cannot be replaced by technological or political fixes, however sophisticated they may be. We now need a concerted effort to develop further this fourth kind of information; we are already reasonably well served with respect to the first three types. Our advocacy of designation of the Long Point ecosystem as a Biosphere Reserve would foster the evolution of information services on the state of the ecosystem (Section 4.3). In fact the entire Long Point ecosystem could and should be used as a barometer of how well the whole Great Lakes Basin, with its overlying airshed, is being managed.

When we must face difficult decisions, we seldom if ever have as much information as we would like to have. Presumably this will be true indefinitely into the future, in part because human and ecological natures tend to shroud their deeper mysteries from our curious gaze and meddlesome analyses. But we know and understand enough so that the haphazard decisions of the past must not resurface to be the primary way of coping with Long Point. A more co-operative, deliberative, normative form of governance that seeks to husband and foster the highly valued features and processes so dependent on a healthy, self-regulating state of the man-nature ecosystem, is evolving. In a sense, our work is an exposition of that evolutionary process. The leaders of that process may not themselves be fully aware of the importance of their innovations; our work is in part a celebration of their achievements to date.

On the whole, binational governance of the Great Lakes Basin is not yet enthusiastic about the ecosystem approach, though commitment to it is growing, apparently rapidly. The Long Point ecosystem should be managed so as to serve as an example for other component ecosystems of the Great Lakes Basin and for the entire Basin itself. Some facilitating arrangements would be timely to consider in order to bring this about. We propose one such arrangement below.

4.3 A Biosphere Reserve for the Long Point Ecosystem

4.3.1 The Concept

We have discerned that those agencies responsible for particular adminstrative or management units within the Long Point ecosystem do see advantages in relating their particular efforts to the shared goals for this ecosystem. Some progress is being made in this direction. It is evidenced by the cooperative work of the NEC, and the consultation processes to develop the management plan for the National Wildlife Area. Further evidence comes from the inherently more extensive planning and decision procedures required by the Haldimand-Norfolk Regional Official Policies Plan, the Long Point Region Conservation Authority's Watershed Plan, and the Ministry of Natural Resources' District Land Use Guidelines. These cooperative networks could be linked, extended, or modified in some manner to provide sufficient scope for the information exchange and cooperation needed to enhance and maintain coherence among diverse program activities affecting the whole Long Point ecosystem.

There are a number of possibilities for bringing this about. We were struck by the congruence between the approach we have been advocating, the situation presented by the Long Point ecosystem, the stated goals of the Unesco "Man and the Biosphere Programme" (MAB), and the criteria for nominating biosphere reserves in Canada (Francis 1982).

Unesco/MAB has, since 1971, been advocating a much stronger and more sustained effort from countries throughout the world toward interdisciplinary, management-oriented, ecological research and monitoring, viewing this as an essential prerequisite for sensitive and effective management of natural resources. In order to help focus this effort on representative examples of the world's major ecosystems (biogeographic provinces), Unesco/MAB has adopted the concept of a biosphere reserve as areas in which this kind of research and monitoring would be developed and demonstrated.

The concept of a biosphere reserve can be viewed as a logical next step in the evolution of thinking about national parks, ecological reserves, or equivalent protected areas (Batisse 1982; Maldague 1984). The reason for protecting such natural areas is to conserve examples of biotic diversity, in part for their intrinsic values, but also to keep open opportunities for basic ecological research and the monitoring of fluctuations and change in different ecosystems. A biosphere reserve extends this further. It is organized to incorporate a protected core of relatively undisturbed landscape such as an existing ecological reserve, but includes with it some of the adjacent areas that demonstrate some ways in which similar landscapes are managed and used to meet various human needs. Within each biosphere reserve, arrangements are made to bring together people who own or manage different units, including the protected core area, with persons from organizations doing research, monitoring, or educational work in the reserve or nearby. The intent is to enable this group to develop and help carry out management-oriented research and monitoring activities that address locally identified resource management issues. A biosphere reserve is really an international designation of recognition for the agencies that receive it, and can be used as the occasion to strengthen cooperation along the lines noted.

Unesco/MAB can be seen as a successor to the International Biological Programme, which in the 1960's fostered the establishment of ecological sites and encouraged basic ecological research to be done throughout the world. Unesco/MAB is striving to have at least one, and preferably several, biosphere reserves recognized for each of the world's biogeographic provinces. The goal is to create a global network of such areas that collectively will exemplify all of the world's ecosystems and the different patterns of human use and adaptations to them. Some 226 biosphere reserves have been designated in 62 countries as of September 1983 (IUCN 1983).

4.3.2 A Long Point Biosphere Reserve

The Long Point ecosystem would be an excellent area to nominate as a biosphere reserve. As a total ecological complex it represents some characteristic features found in the lower Great Lakes in particular. The Great Lakes are recognized as one of the world's biogeographic provinces in the global classification system used by Unesco/MAB to develop a representative system of biosphere reserves (Udvardy 1975). The Long Point component of the National Wildlife Area and properties of the Long Point Company meet the criteria for the core zone of a biosphere reserve, and other components of the complex represent different mixes of resource use and management practices. Although the determination of some outer limits of a surrounding buffer zone for each biosphere reserve is necessarily set rather arbitrarily, a case could be argued for Long Point that the 100-year flood line on the mainland side and the 10-m depth contour in the surrounding waters are systemically significant. The depth contour includes the limit of active shoreline erosion and deposition processes and coincides with the average depth of the summer thermocline in that portion of the Lake Erie basin.

Should this concept of a biosphere reserve be applied to the Long Point ecosystem, it would include a number of major ownership and management units that comprise the total area. The key factor for making the most use from a Unesco/MAB designation is for all the "actor" organizations who have a stake in the larger complex to come together under the umbrella of a biosphere reserve. This provides an opportunity for them to cooperate on identifying resource and environmental management issues of mutual concern and work toward developing appropriate management-oriented ecological research and monitoring. It also provides opportunities for carrying out comparative studies of areas subjected to various patterns of use and management with ecologically comparable areas protected in the core of the biosphere reserve. Ultimately, as already noted, the full potential of the biosphere reserve concept is expressed in the nature of the cooperative work it can help foster among all concerned. The potential is impressive.

4.4 A Closing Editorial

Our approach to the Long Point ecosystem could be viewed as a reformulation of traditional values and truths that lie deeply nested, but often suppressed, within the culture of many people in the Long Point region. If an underlying, ongoing commitment to ecosystem husbandry and stewardship by at least some key users, interests, and opinion leaders had not existed, then the Long Point ecosystem would not have survived in a reasonably healthy state for decades after some parts of Lake Erie had become seriously degraded. We celebrate the stewards and husbandmen of Long Point and reaffirm the enduring values and verities. The Long Point ecosystem has not been addressed in exactly the manner we have now suggested, yet this is compatible with the commitment of many long-time residents of the area, i.e., with the fishermen, hunters, and farmers; and with the amateur naturalists and with professionals in many kinds of services. All these together have been effective in conserving many of the natural features of the Long Point ecosystem.

Key aspects of the ecosystem approach as we have viewed it are captured by alliteration, a use of four sibilants which themselves are suggestive of the sounds and sights of the waters, marshes, and sands of Long Point: *sensitive, sustaining, sufficient,* and *systemic.* The corresponding concepts should be affirmed as strong normative guidelines concerning collective human activities here and elsewhere in the Great Lakes.

Hence, those who would gamer benefits from the Long Point ecosystem must intervene *sensitively.* It is a fragile network of many kinds of creatures and different land forms. Stewards and husbandmen-whether of waters, marshes, lands, or forests-know what it means to act with sensitivity. On many important decisions the planners, managers, developers, and industrialists must simply defer to the advice of the more knowledgable stewards and husbandmen. Ecosystem abuse must end, and with it the indirect abuse of this ecosystem's sensitive users.

For as long as humans continue to inhabit this earth *we* will be *sustained* by healthy ecosystems. Perhaps the period of the most unsustainable practices is already behind us in the Great Lakes. Ecologically sensitive, highly valued fish and birds are beginning to reappear and recover in numbers even in some of the most degraded parts of the Basin. But a serious relapse cannot be dismissed as unlikely. Humans make errors. It is also not difficult to find powerful political and private interests that are ignorant or insensitive about the key roles of healthy ecosystems in human affairs. Long Point should serve as a model for sustainable use. It could also become a model for those high quality sustainable benefits that may yet be recovered in coastal zone ecosystems that are now degraded because of exploitive misuse and unsustainable overuse of the past and present.

Sensitive husbandmen and sustainable use imply an appreciation of what is *sufficient.* Ecosystemic benefits are usually available only in modest to moderate quantities if these benefits are to be of high quality. The tradeoff between quality and quantity of benefits is quite sharp; this is a fact well appreciated by those who keep watch over fish and wildlife, or who must contend with recreational visitors to attractive, yet sensitive, landscapes.

A clear sense of *sufficiency* must relate not only to the use of ecosystem features and products, but also to the management of the users. Husbandmen and stewards need not be subjected to extensive supervision if the relevant societal institutions are structured to foster more self-regulation within and among the users themselves. External coercive governance should be directed at the intrusions of ecosystem abusers. Local participatory self-governance should prevail among the husbandmen and stewards. Thus a sense of sufficiency with respect to external formal governance should follow from a recognition of what the specific needs are for such governance; those needs often relate to the insensitive intrusion of external interests.

All three of the preceding normative concepts are also caught up in the fourth-to participate *systemically* as a symbiotic, compatible component in the ecosystem. When seeking to correct an abuse, it is necessary do so incisively and systemically, and strive to address the root cause of the problem rather than attempt a quick fix. When harvesting a species of fish or other renewable resource carelessly or unsystemically, expect ecological consequences to ramify to other species with consequences that may be undesirable.

As with other ecosystems, but more so than with most, Long Point is forever in flux. The changes are usually incremental but occasionally they show dramatic though temporary manifestations. *Systemic* involvement must therefore be flexible and adaptive and ultimately expectant of surprise. Hence governance for Long Point requires the capacity to monitor and adapt to these changes as well as the ability to manage the sensitive uses.

The two binational commissions with responsibilities for the Great Lakes are now firmly committed to an ecosystem approach for dealing with the problems and opportunities presented by these magnificent freshwater resources. The Great Lakes Fishery Commission first confirmed this implicitly through its sponsorship of our Great Lakes Ecosystem Rehabilitation working group (Francis and Regier 1977), then much more explicitly by its Policy of Commitment to an Ecosystem Approach (GLFC 1980a) taken at about the same time it developed the framework for its Joint Strategic Plan for Management of the Great Lakes Fisheries (GLFC 1980b).

In a somewhat parallel development, the International Joint Commission dealt with the concept in reports presented through its Science Advisory Board (IJC/SAB 1978, 1979). The terminology and implicitly the commitment to an ecosystem perspective was affirmed by Canada and the United States in the 1978 Great Lakes Water Quality Agreement. More recently (IJC 1982), in its first biennial report under the 1978 Agreement, the International Joint Commission declared itself unequivocally as follows when it pointed to the directions which must be pursued.

> The Commission recommends therefore that the Parties, Jurisdictions and others foster and encourage policies, programs and institutions that:
>
> (a) help develop and maintain a long term ecosystem perspective with respect to the pursuit of its other legitimate goals and to be more anticipatory in its actions;

(b) encourage research, monitoring and analysis of man's impact on ecosystems in order to facilitate personal and institutional actions that are consistent with ecosystem realities;

(c) help make scientific and technical information about man's place in nature more accessible, understandable and relevant to the individual citizen;

(d) encourage citizen involvement in identifying and shaping long term ecosystem goals in order to build greater community consensus and commitment; and

(e) encourage non-adversarial measures for preventing and resolving conflicts arising over the use of shared air and water resources.

We believe that our prospectus on Long Point has developed normative yet operational guidelines for implementation of an ecosystem approach to one small, but very significant, component of the Great Lakes Basin Ecosystem. We have sought to integrate information from all the major binational programs and meld it with information from all other levels of governance. We hope that this synthesis of information will help foster further development of a sensitive, sustaining, sufficient, and systemic ecosystem approach to Long Point, in part through a recognition that it qualifies as a biosphere reserve of global significance. This should provide a convenient forum for the ecosystem husbandmen and stewards to improve the necessary self-governance of human activities in the Long Point ecosystem.

In conclusion, we challenge all those who are also committed to advancing the ecosystem approach to work toward devising feasible, operational expressions of it for other areas within the Basin. By discovering what it would take to accomplish this "on the ground" at other sites and under other circumstances, we could then better understand what we must also do collectively through the binational commissions and other instruments of governance.

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