

TOWARDS AN ECOSYSTEM APPROACH TO LAND-USE PLANNING

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TOWARD AN ECOSYSTEM APPROACH TO LAND-USE PLANNING

Ecosystem Planning Series: Introduction

Environmental Planning & Analysis Branch
Ontario Ministry of Environment and Energy

Project Team

David A. Neufeld, Rick Cockfield, Bonnie Fox, Graham Whitelaw

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1.0 THE NEED FOR AN ECOSYSTEM APPROACH TO LAND-USE PLANNING

In North America, attempts to integrate environmental considerations into land-use planning span more than a century, with their roots in the conservation, city planning, and rural planning movements (see Toner 1988). This work has been carried on in Ontario by such notables as Robert Dorney (1989) and Michael Hough (1990), among others.

Recently, environmental perspectives on land-use planning have gained broader acceptance among politicians, government agencies, professionals, academics, and interest groups. There is general agreement that the current process does not provide a satisfactory means of protecting the environment, particularly in terms of the negative cumulative environmental effects of development.

The need to adopt an ecosystem approach has been reinforced by the many reports and recommendations of the Royal Commission on the Future of the Toronto Waterfront (1990a, 1990b, 1991, 1992); the Commission on Planning and Development Reform in Ontario (1992); the Ontario Round Table on Environment and Economy (1990, 1991); the Premier's Council on Health, Well-Being and Social Justice (1991); the Environmental Assessment Advisory Committee (1988, 1989, 1990a, 1990b); and the Conservation Council of Ontario (1986).

Integrating ecosystem considerations into planning will help prevent development decisions from prejudicing future ecosystem and human health. At the same time, ecosystem planning will mean significant savings since the need for costly and difficult remedial action after the fact should be avoided. Moreover, ecosystem planning should result in a more efficient development review process because it provides better up-front guidance on the location, type, and timing of development.

2.0 THE MINISTRY OF ENVIRONMENT AND ENERGY AND THE ECOSYSTEM APPROACH

The Ministry of Environment and Energy (MOEE) believes that an ecosystem approach to land-use planning should be adopted in Ontario. The ministry's environmental strategy is to move toward prevention and avoid further environmental damage. Its fundamental purpose, according to its statement of goals, is:

to achieve and maintain a quality of the environment - including air, water and land - that will protect human health and the ecosystem and will contribute to the well-being of the people of Ontario.

In its participation in the major land-use planning policy initiatives of the Ministry of Municipal Affairs and in the deliberations of the Sewell Commission, the MOEE has argued that an ecosystem approach should be the foundation for managing growth and that an environmental framework provides the basis for a new set of land-use planning values.

In November, 1991, the ministry decided to take the first steps toward refocusing its involvement in land-use planning. The long-term goal is to ensure that an ecosystem approach is adopted in Ontario, and that municipalities adopt comprehensive environmental policy frameworks in their official plans. The ecosystem approach and cumulative environmental effects assessment have been identified as high-priority areas for which policy direction is needed.

Developing a position on ecosystem planning is part of the MOEE's contribution to discussions on integrating environmental considerations and priorities into the planning process. It will also help the ministry assume a leadership role in promoting comprehensive ecosystem planning. This document sets out the requirements and advantages of ecosystem planning; existing literature is mentioned throughout, with references listed at the end of this document.

3.0 PURPOSE AND ASSUMPTIONS

The purpose of MOEE's ecosystem planning initiative is to outline the ministry position on an ecosystem approach to land-use planning and cumulative effects assessment, and to identify the implications for the municipal planning process. In addition, there are six fundamental assumptions on which the initiative is based:

- MOEE is committed to implementing an ecosystem approach in land-use planning;
- the approach provides the context within which cumulative environmental effects can be assessed;
- there is a need to move beyond generalizations to specific and practical means for implementing an ecosystem approach;
- the ecosystem approach requires a comprehensive view of land-use planning in the context of related MOEE programs and of the programs of other ministries;
- the initiative is divided into phases because of the complexity of the issues, and to provide opportunities for mutual understanding and learning at all levels within and among affected ministries and stakeholders;
- ultimately a provincial (inter-ministry) ecosystem approach to land-use planning is required if such planning is to be implemented successfully.

4.0 OBJECTIVES

As the first step of the ministry's initiative on ecosystem planning, the objectives of this background report are to:

- review key concepts and characteristics associated with an ecosystem approach;
- identify key MOEE issues and progress in implementing such an approach;
- provide the context for future actions to encourage and facilitate progress at the municipal level in implementing an ecosystem approach.

5.0 BACKGROUND TO THE MUNICIPAL LAND-USE PLANNING PROCESS

The *Planning Act* establishes the ground rules for municipal land-use planning in Ontario. It defines procedures and requirements for: local planning administration; preparing municipal official plan policies to guide future development; regulating land use through zoning by-laws; subdividing land; public notice of planning proposals; public meetings before municipal councils; and appeal procedures before the Ontario Municipal Board.

The Ministry of Municipal Affairs administers the Act and currently has authority to approve such policy documents as official plans and such development proposals as subdivision plans. The Minister of Municipal Affairs also has the authority to delegate approval functions; since 1975, authority to approve plans of subdivisions have been delegated to regional governments, select counties/districts, and separated cities. Authority to approve local official plans also has been delegated to a number of regional governments that have approved official plans.¹

The Minister of Municipal Affairs has the authority to issue policy statements, alone or jointly with other ministers, in order to guide planning authorities on matters of provincial concern. Municipalities and the Ontario Municipal Board, as well as provincial agencies, are required to have regard to these policy statements when making planning decisions. To date, four policy statements have received final approval by Cabinet, in relation to: mineral aggregates, floodplains, wetlands and housing.

The *Planning Act* requires that such agencies as the MOEE are afforded an opportunity to submit comments to the planning authority on planning policy documents as well as on development proposals. Such comments are advisory only, and the decision on approvals of an official plan, plan amendment, or development application is the responsibility of the Minister of Municipal Affairs or the delegated authority. However, modifications may be required or imposed by the Minister of Municipal Affairs as a result of staff input.

¹ No municipality has the authority to approve its own official plan or amendments to that plan.

An individual or agency that still has concerns may ask the Minister of Municipal Affairs to refer planning decisions to the Ontario Municipal Board.

With some notable exceptions, all regional and many local municipalities in Ontario have approved official plans that provide the policy framework for their land-use planning. Official plans designate lands for certain specified uses, outline policies to guide future development, and provide the basis for adopting legally enforceable zoning by-laws.

Municipalities that have adopted and implemented a comprehensive environmental framework within their official plans will find that doing so promotes active protection and enhancement of the environment, and should also facilitate a streamlined development review process. Environmental policies in municipal official plans vary, but general policies setting out broad goals for environmental quality and protection often are included. In addition, sections may contain more specific environmental policies related to transportation, infrastructure, noise, water quality and environmentally sensitive areas.

Recent municipal interest in the environment has been expressed through studies dealing with such matters as groundwater resources and greenland strategies, support for watershed studies, and vision statements. Some municipalities have environmental advisory committees, while others have established round tables on environment and economy to give them multi-sectoral advice on ecological and sustainable development issues. In a few cases, municipalities have issued state-of-the-environment reports as a basis for assessing environmental progress within their borders.

6.0 THE ECOSYSTEM APPROACH

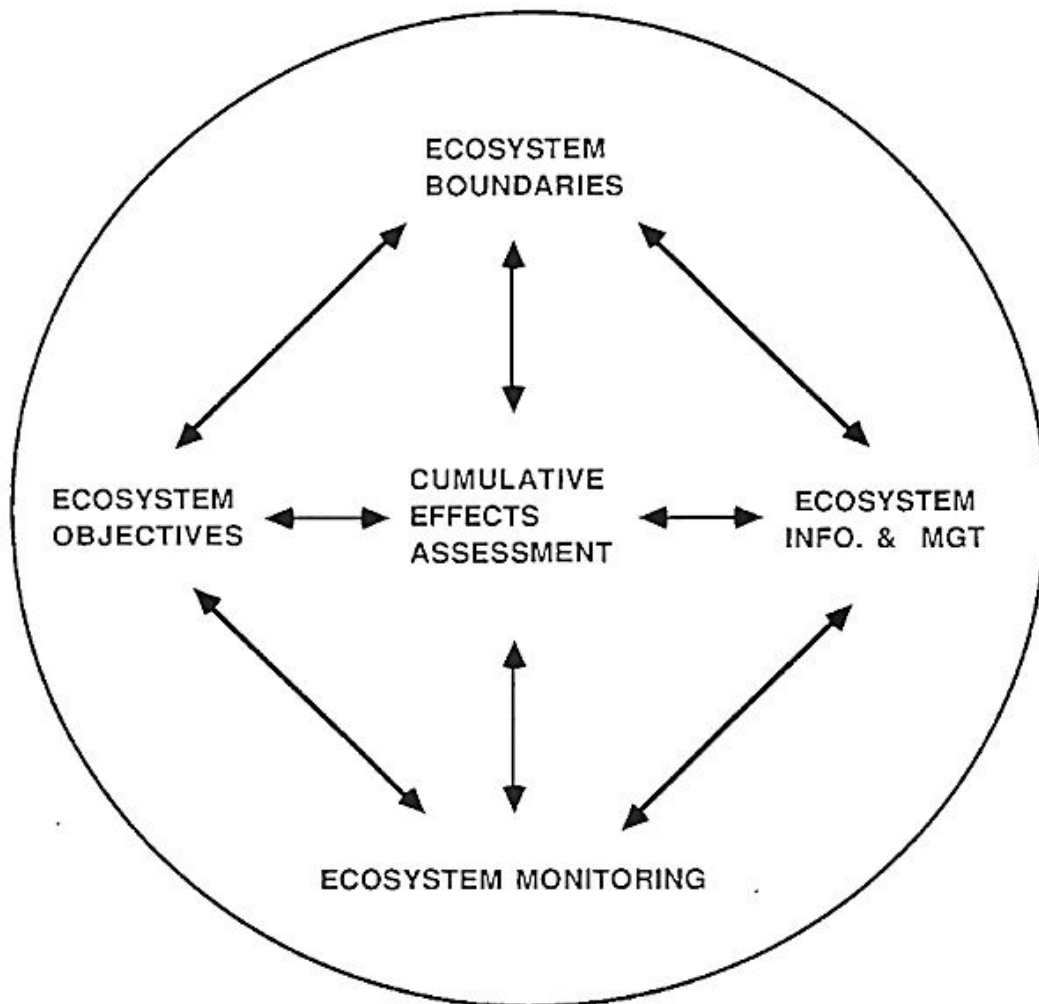
An ecosystem approach requires an ecological context for decision-making, reflecting an evolution in the way we assess and manage the impact of human activities on the natural environment. An ecosystem approach to land-use planning provides early and systematic guidance on the inter-relationship between human activities (existing and planned) and ecosystem health and integrity over time. It means treating ecological goals equally and simultaneously with economic and social goals. It is based on recognizing that there are limits to the degree of stress ecosystems can accommodate before they are irreversibly degraded or destroyed.

An ecosystem approach also implies broadening the traditional tendency of environmental protection from focusing on considerations of human health, to include the health of ecological systems -- acknowledging that human health and welfare ultimately rely on them. In that context, it regards humanity as part of an interconnected, interdependent global ecosystem in which changes to one part may affect other parts in unexpected ways (Science Advisory Board 1990:9).

There are five major components to an ecosystem approach for land use planning:

- a. boundaries for planning purposes;
- b. environmental objectives and targets;
- c. assessments of cumulative environmental effects;
- d. information collection and management;
- e. monitoring that is carried out.

FIGURE 1: Inter-dependent Components Of Ecosystem Approach.



6.1 Boundaries

An ecosystem approach recognizes the need to use biophysical boundaries as the context within which interactions between human activities and the natural environment are assessed. This contrasts with the traditional approach in which goals, objectives, and activities are formulated and evaluated solely within political and administrative boundaries.

Ecosystem units can be defined at different scales or levels that are nested within, and overlap, each other. For example, three different scales include the bioregion, watershed catchment basin, and watershed sub-basin (CCME 1991). Of those three, the ecological unit commonly recommended for ecological planning is the watershed (Odum 1971; Imhof *et al.* 1991). The hydrologic (water) cycle is a pathway that integrates the ecosystem's physical, chemical, and biological processes. However, other biophysical boundaries, including those that are defined physiographically, may be appropriate. Boundaries may be chosen as a function of planning issues: the appropriate scale must reflect the impact and concerns that have been identified in the planning process (Gosselink and Lee 1987; Great Lakes Advisory Board 1978).

Time is also important as a boundary: the dynamic nature of ecosystems means that their ability to adapt to anthropogenic stress and natural disturbances varies over time and this evolution must be taken into account (Regier 1991). This is particularly important in light of the practical irreversibility of human impact on ecosystems (Gosselink and Lee 1987).

6.2 Ecosystem objectives

Planning according to an ecosystem approach means that ecosystem objectives must be defined and subsequently incorporated into decision-making processes. In addition to the practical difficulty of restoring severely degraded ecosystems, dealing upfront with ecosystem matters avoids the need to spend vast amounts of money in future remedial attempts.

Ecosystem objectives should be based on the goal of maintaining or restoring ecosystem health and integrity. When there is conflict between planning objectives, ecosystem health should have priority. Objectives should also be the basis for setting standards being applied to development. However, the detail of objectives will depend on the ecosystem scale being used for planning purposes (CCME 1991).

Developing ecosystem objectives flows from an understanding of ecosystem health and is based on shifting away from dependence on numeric measures of pollution as the standard of success for achieving environmental goals. Instead, broader, more holistic measures of ecological health are needed, based on appreciation of the environmental processes and patterns that control ecosystem dynamics (Karr 1991; Gosselink and Lee 1987).

There is no simple way of defining or measuring ecosystem health (Schaeffer *et al.* 1988). Generally, however, ecosystem objectives should focus on protecting the self-organizing, self-integrative, naturally regenerative abilities of an ecosystem (see, for example, Karr 1991; Regier 1991). In broad terms, this would include maintaining natural ecological processes and biological diversity.

Ecosystem objectives may be stated in terms of indicator species, environmental quality criteria, habitat suitability, and a desirable network of natural nodes and corridors (greenways or green infrastructure). Objectives should be translated into measurable targets (e.g., percentage of wetland areas, forest cover, riparian stream habitat protected or restored) to be used as benchmarks against which proposed human activities can be assessed and ecosystem health can be monitored over time.

Deciding on the desirable level of ecosystem health is a social process requiring the full participation of stakeholders, co-operation among all affected governments and input from such disciplines as: ecology, hydrology, hydrogeology, planning, engineering, economics, and sociology (Gosselink and Lee 1987; Sonntag 1987; Horak *et al.* 1983; CEARC 1986).

6.3 Information requirements and management systems

An ecosystem approach to land-use planning should be based on synthesizing information on the structural and functional relationships among air, land, water and a particular ecosystem's organisms over time. In particular, functionally related parts of the ecosystem must be properly identified and considered. Information must be based on the entire ecosystem and be supplemented, where and when necessary, with site-specific information. It must include historical data drawn from existing material or obtained by comparing similar ecosystems according to the degree of development within each; it must be linked to ecosystem function.

There is a need to do more than resource surveys: those parts of the ecosystem that are functionally related must be properly identified and considered (Great Lakes Advisory Board 1978). Structural information can be mapped, focusing on selected features in a given planning area. Functional information also can be mapped to delineate areas within which major ecological processes occur. Combined, these components enable planners to base their decisions on delineated areas of significance and constraint (Bastedo *et al.* 1984).

Ecosystem synthesis must be undertaken in a manner that makes data relevant to the planning in question. For example, the percentage of wetland within a watershed might be mapped. However, determining the functional role of these wetlands would be a more significant contribution to the planning process.

An ecosystem approach to land-use planning also means integrating information into a common data-base network that is available to all participants. There is a need for an information management system capable of integrating diverse data sets, processing and evaluating data collected over a long period, relating data to physical space and making it possible to share complete, accurate, and timely data among agencies.

The analysis of information about spatially related environmental elements, typical of the data used in an ecosystem approach, becomes more complex as more data and more data sets are collected; this leads, in turn, to more complex assessment and decision-making. Geographic information systems can be used to compile, process, retrieve, and assess complex data for specific geographic areas over long periods and to facilitate comparisons of historical data and present conditions, within defined boundaries (Sparrow 1991; Johnson et al. 1988; Horak *et al.* 1983). A Geographic Information System (GIS) has been defined as:

... a tool for decision making and an aid for planning and development, which consists of a data base containing spatially referenced land-related data, as well as the procedures and techniques for systematically collecting, updating, processing and distributing that data.

Dangermond and Freedman 1986

6.4 Assessment of cumulative environmental effects

The literature indicates that, because they interact with the pre-existing effects of similar or dissimilar stressors (Davies 1991a), all environmental effects can be described as cumulative. Cumulative environmental effects have been categorized as follows:

- a) time crowding: the frequent and repeated impact on a single environmental medium;
- b) space crowding: many effects on a single environmental medium;
- c) compounding effects: synergistic effects arising from multiple sources on a single environmental medium;
- d) time lags: long delays before the impact becomes clear;
- e) extended boundaries: the impact that results from distance from source;
- f) triggers and thresholds: disruptions of ecological processes that fundamentally change system behaviour;

- g) indirect effects: secondary impact resulting from a primary activity;
- h) patchiness effects: fragmentation of ecosystems.

CEARC 1988, Bedford and Preston 1988, Davies 1991b

Initial efforts to develop a methodology of assessment that accurately reflects cumulative environmental effects concentrated on the scientific assessment of the effects of activities on the physical and natural environment.² For the purposes of this discussion, cumulative effects assessment is understood as the quantitative assessment of the cause-effect relationships by which human activities are manifested in the ecosystem as biophysical effects. Any number of specific scientific techniques may be used in some combination as a methodology to assess or predict the potential effects of a collection of stressors on the health of an ecosystem. These techniques might include:

- cause/effect relationships
- checklists
- mapping and overlays
- trend analysis and forecasting
- weighting and evaluation techniques
- cluster impact assessment
- adaptive procedures
- modelling
- matrices
- risk assessment
- networks
- loop analysis
- biogeographic theory
- ad-hoc attempts

The relationship between the categories of cumulative environmental effects and the manner in which they are manifested in the environment through functional pathways is outlined in Figure 2. A great deal more research is required if we are to properly understand the cause-effect relationships that characterize the pathways and the functional and structural processes of ecosystems that lead to cumulative environmental effects. This is particularly true with respect to compounding effects (CEARC 1988). Moreover, the diversity of cumulative environmental effects makes it extremely difficult to develop broadly applicable cumulative effects assessment methods (Davies 1991a).

² The legislative requirement in the U.S. National Environmental Policy Act (NEPA, 1969) requiring assessment of cumulative effects has stimulated extensive research, especially in the areas of study related to wetlands preservation and hydroelectric development.

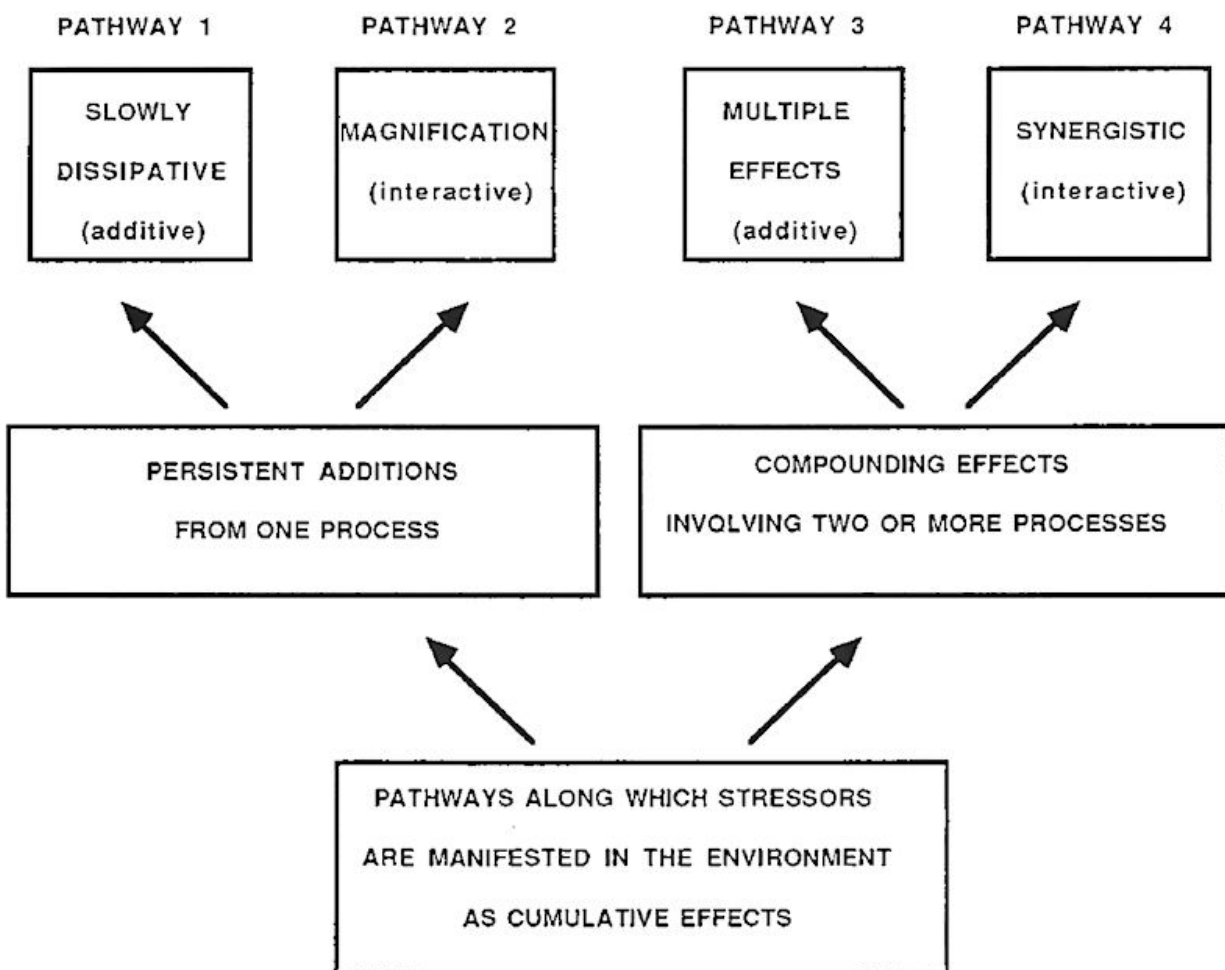
The techniques are currently being applied, recognizing that most cannot effectively address multiple projects; the interaction of multiple resources and effects; and second-order, indirect, temporal or spatial effects (CEARC 1988, Hubbard 1990, Davies 1991b). Assessments of cumulative environmental effects have been attempted either in response to development that has the potential to stress° the ecosystem (e.g., a hydroelectric project) or in response to stresses threatening a particularly valued ecosystem (e.g., a wetland). Both make clear the inadequacies of current cumulative effects assessment because they are reactive and because they do not have the context of a comprehensive area plan, proven methods of quantifying or predicting cumulative effects, or an adequate integrated information data base (Cada and Hunsaker 1990). The limited application of cumulative effects assessment has usually focused on such first-order effects as habitat-related losses because conventional ecological analysis has evolved around habitat-based indicator-species correlations. Second-order effects (time-crowding, space-crowding, indirect and delayed effects, and synergisms) resulting from interactions with other ecosystem activities are not considered at present. Also there is no practical method for assessing the cumulative environmental effects of various stresses at different sites, scales, and periods of time.

Initial attempts at assessing cumulative effects have evolved into a broader approach that involves assessing the impact on the ecosystem in the context of societal goals and objectives (Stakhiv 1988; Bardecki 1988; Gosselink and Lee 1986; and CEARC 1988). The broader interpretation incorporates an assessment of cumulative environmental effects within an ecosystem approach.³ As stated by Davies (1991b:14):

... concepts and definitions of cumulative environmental effects have evolved over time from an initial understanding of the biophysical considerations involved to a recognition that assessing cumulative environmental effects requires combining scientific information and criteria and human values in a goal-oriented planning process for variable, but extended time frames and spatial boundaries.

³ There are two interpretations of CEA in the literature (Hubbard, 1990). The first is the scientific assessment of the effects of activities on the physical and natural environment. The second interpretation of CEA involves assessing the consequences of human activities as measured against desired goals and objectives, rather than having the human activities comply with absolutely stated criteria or minimal standards as is the present situation (Stakhiv, 1987; Bardecki, 1988; and Gosselink and Lee, 1986).

FIGURE 2 : Functional Pathways Of Cumulative Effects.



The following are examples of cumulative effects and the functional pathway(s) through which they are manifested in the environment:

- Time-crowding through pathways 1 & 3
- Space-crowding through pathways 1 & 3
- Compounding through pathways 2 & 4
- Time lags through pathway 1
- Space lags through pathways 1 & 2
- Indirect effects through potentially all of the pathways
- Patchiness (nibbling) through potentially all of the pathways

(Peterson *et al.*, 1987, as modified from CEARC, 1988)

When used to define an ecosystem's biophysical functions and processes, as well as its response to human-induced stresses, cumulative effects assessment provides the ecological bottom line that can be used as a benchmark against which the objectives of ecosystem health can be evaluated. However, effective cumulative effects assessment cannot occur without the other components which are part of the framework of an ecosystem approach. Furthermore, cumulative environmental effects only can be addressed constructively at the project level if they have been considered in developing a plan for an area or region (Davies 1991b:60). It must, therefore, take place at the same time as, and in conjunction with, decisions regarding ecosystem objectives, boundaries, and information needs. When that occurs, cumulative effects assessment provides the foundation on which to predict the impact of different levels of development on ecosystem conditions. In that way it is possible to reach decisions that are based on a clear understanding of ecological consequences.

6.5 Monitoring

An essential component of the ecosystem approach to planning is monitoring (CEARC *et al.* 1986; Horak *et al.* 1983). A monitoring system should provide information on whether ecosystem objectives are being met and should help assess how effective the planning decisions were in achieving ecosystem objectives for the planning area. Specifically, the goals of ecosystem monitoring should be to:

- understand long-term changes in the ecosystem;
- identify baseline conditions;
- follow ecosystem response to specific threats;
- ensure specific conditions are maintained.

Woodley 1991

Variables that are representative of stress on ecosystems should be monitored; as well, the overall state of ecosystem health should be monitored, using indicators of an ecosystem's vital signs. Biological response to stress has been examined at the individual, population, community, ecosystem, and landscape levels (Karr 1991:81); monitoring could be carried out at all levels (Woodley 1991).

A selection of indicators can be combined into a single index of ecosystem integrity to detect degradation and identify its causes, to assess whether certain actions result in improvements, and, ultimately, to reformulate standards and requirements in order to prevent ecosystem degradation (Karr 1991:70).

Environment Canada is examining the development of a National Environmental Monitoring Program; the work has focused on three general categories of indicators:

- stressor indicators: socioeconomic, demographic, and regulatory compliance measurements of stress; examples include pesticide applications, pollution emission inventories, land use
- exposure indicators: these incorporate such factors as amounts, rates, and accumulation of pollutants; examples include ambient pollution concentrations, acidic deposition, toxic bioaccumulation
- response indicators: these quantify the response of ecosystems to stress; examples include indices of community structure and diversity, fish tumours, habitat loss, species loss.

Freedman *et al.* 1992:20

The first two indicators are designed to assess threat-specific factors and the third to measure ecological integrity. Two classes of monitoring sites (intensive and extensive) for each identified ecozone in Canada are being evaluated for use in the Monitoring Program. The intensive sites would be used for relatively detailed monitoring of structural and functional integrity, while extensive sites would be more numerous and located throughout each ecozone to gain an overview of large-scale changes in the ecological character of the landscape (Freedman *et al.* 1992).

7.0 MOEE CASE EXAMPLES OF THE QUALITIES OF THE ECOSYSTEM APPROACH

MOEE has been active in a number of important efforts to promote broader approaches to maintaining or restoring ecosystem health. The following nine examples incorporate one or more aspects of an ecosystem approach.

7.1 The Niagara Escarpment Program

The Niagara Escarpment Plan is the best example in Ontario of the use of a physiographic landscape feature as an ecological unit for planning purposes and has been recognized by the United Nations as a Biosphere Reserve. The Niagara Escarpment Plan is regionally based on landform/social boundaries. The plan boundary, as delineated, has resulted in a comprehensive planning approach that considers all individual projects within the context of the entire plan area. The plan takes a long-term perspective. In most cases, once a particular area's development potential has been reached, no further development will be permitted.

The *Niagara Escarpment Planning and Development Act* has an environmental purpose and objectives that translate into a planning and regulatory framework; the purpose of the act is:

...to provide for the maintenance of the Niagara Escarpment and land in its vicinity substantially as a continuous natural environment, and to ensure only such development occurs as is compatible with the natural environment.

Some of the objectives of the Act are:

- to protect unique ecologic and historic areas;
- to maintain and enhance the quality and character of natural streams and water supplies;
- to provide adequate opportunities for outdoor recreation;
- to maintain and enhance the open landscape character of the Niagara Escarpment in so far as possible, by such means as compatible farming or forestry and by preserving the natural scenery;

The environmental goal and objectives were incorporated into the Plan after extensive public, agency, and special interest consultation, which transformed environmental objectives into socially acceptable policies. For each designation, trade-offs between environmental protection and development are understood and, as a result, uses range from no development to urban forms of development.

Extensive resource survey information was utilized during the development of the plan and a multi-disciplinary approach was also used. No cumulative effects techniques were used either in preparing the original plan or in implementing it since 1985. However, it should be noted that the plan requires consideration of cumulative impact. Sections 2.2.1 a) and b) of the general development criteria require that:

- the long-term capacity of the site is able to support development without substantial negative impact on the environmental features of the Escarpment;
- the cumulative impact of development will not have a serious detrimental effect on the environment of the Escarpment.

Work is being initiated to identify how these provisions might be implemented. Environmental monitoring is recognized as an important program-related function in MOEE's

Niagara Escarpment Program. In partnership with MNR, the Niagara Escarpment Commission and other interested groups, MOEE is developing a monitoring program that assesses cumulative effects (MOEE, 1994). A component of the monitoring program will involve setting ecological targets within the context of objectives for the Plan as stated in the Act.

7.2 Remedial action plans

The concept of an ecosystem approach was first applied to the Great Lakes. The principal objective of the 1978 Great Lakes Water Quality Agreement is: "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin ecosystem". The 1987 Amending Protocol called upon all parties to specify ecosystem health criteria for each defined lake ecosystem or portion thereof, in order to be able to evaluate progress towards this objective.

Under the Great Lakes Water Quality Agreement, remedial action plans (RAPs) in Ontario are being developed and implemented to restore water quality in 17 of the most severely polluted locations in the Great Lakes that lie in Ontario's jurisdiction. One of the greatest challenges in the RAP program has been to decide how to apply the concept of an ecosystem approach.

The program is based on the inseparable relationship between land uses and water quality: certainly, the type and intensity of urban and rural land use has played a significant role in impairing Great Lakes water quality.

The RAP process is helping establish a technical link between water quality and loadings from both point sources (e.g., sewage treatment plants) and non-point sources (e.g., agricultural land use). Setting maximum loadings (ecological targets) offers a more complete ecological context for decisions regarding land-use activities and regional growth. It can promote consideration of adaptive and preventive approaches in land-use planning (e.g., better servicing for sewage, stormwater quality management plans).

Through the work of multi-disciplinary and multi-agency RAP teams and the Canada-Ontario Agreement RAP Steering Committee, a strong network and a federal-provincial institutional base have been established under the program, to support the ecosystem approach to planning. Municipalities have been encouraged to become involved and Many are doing so.

7.3 The Lake Simcoe environmental management strategy

The Lake Simcoe environmental management strategy studies were initiated in 1981 in response to concerns about the decline of Lake Simcoe's cold water fishery. The studies concluded that increased urbanization and agricultural activities within the drainage basin were causing excessive amounts of nutrients in the lake.

Because the strategy's goal is to restore a naturally reproducing cold water fishery, there has always been a focus on the ecological framework of Lake Simcoe. The study has attempted to develop methods of predicting changes to protect this ecosystem from further harm and to actually restore it to a level that will allow the cold water fish species at the top of the aquatic food chain to reproduce naturally. Nutrient enrichment resulting from phosphorus loadings was identified as a key problem and is now used in setting clean-up targets and as an indicator of ecosystem health in the lake's cold water fishery.

Implementing the strategy will be affected by two watershed plans currently under way for Lover's Creek and Hewitt's Creek. The object of these plans is to influence land-use activities within these sub-basins (see integrated watershed management below).

7.4 Residential lakeshore development: controlling nutrient enrichment

The ministry's participation in reviewing proposed residential lakeshore development is an example of focusing on a lake basin as the identified ecosystem.⁴ The ministry's involvement in recommending controls on lakeshore development has been based on two main objectives: maintaining water clarity to protect aesthetic (recreational) values; and ensuring that the dissolved oxygen content of lakes is sufficient to support valued fish populations (e.g., lake trout).

Shoreline development in the lake basin is translated into a phosphorus loading value. This anthropogenic phosphorus load is compared to a background condition of total phosphorus concentration in the lake excluding shoreline development. The background condition serves as the baseline for assessing measured conditions at present and any future increases resulting from shoreline development. Cumulative deterioration can be anticipated because the baseline of nonanthropogenic phosphorus load will not change in the future -- only the anthropogenic portions will.

A quantitative model is used to predict phytoplankton concentrations (chlorophyll *a*) based on calculated total phosphorus concentration. Increased growth of algae is associated with decreased water clarity, as well as with reductions in dissolved oxygen, as the result of decomposition.

7.5 Integrated watershed management in Ontario

In keeping with a commitment to work co-operatively in promoting ecosystem objectives, the Ministry of Environment and Energy, the Ministry of Natural Resources, and conservation

⁴ It is being proposed that lakeshore development be considered in the context of the entire watershed, which requires that the trophic status of lakes upstream and downstream from the lake in question be considered.

authorities are supporting the development of watershed studies to provide a context for assessing development pressures and long-term planning.

The focus is to retain natural watercourses and riparian vegetation, enhance stormwater infiltration, prevent soil erosion, promote water conservation, designate environmentally sensitive areas and consider cumulative effects. Enhancing and restoring aquatic environments are also promoted through remediation and redevelopment. Sub-watershed plans will facilitate the consideration of all natural resource features associated with protecting water quality and hydrology, provide for a consistent approach across municipal boundaries and ensure better upfront direction to developers.

These watershed initiatives also reflect the challenge of translating watershed goals and objectives into municipal planning policies and decision-making. At present, success relies on the goodwill of participants and the persuasive powers of participating provincial agencies. Integrated watershed management requires partnerships, with all municipalities in a watershed area being represented, and a willingness by all parties to make their daily planning decisions on the basis of these plans. The watershed management and planning process is detailed in the three watershed documents entitled: *Watershed Management On A Watershed Basis: Implementing An Ecosystem Approach*; *Subwatershed Planning*; and *Incorporating Water Management Objectives into Municipal Planning Documents* (MOEE and MNR, 1993).

In a regional exercise the staff ecologist in MOEE's southwestern region is developing a predictive model to assist in defining the carrying capacity for development within watersheds or catchment basins. It involves mathematically modelling the relationship between water quality at the base of the basin and land use within the basin. Benthic macro-invertebrates have been chosen as the indicator of water quality because they represent the integrated effect of all environmental variables during the period they have lived in the habitat. Development unit values are assigned to various land uses; these are based on the expected impact of the type of development on the quality of aquatic biota.

7.6 Oak Ridges Moraine study area

The province's expression of Provincial Interest in the Oak Ridges Moraine, announced in June 1991, is another example of using a physiographic landscape feature as an ecological unit for planning purposes. The special significance and sensitivity of the moraine led the province to announce measures designed to increase the protection afforded it. The Oak Ridges Moraine Implementation Guidelines and the co-ordinated provincial review process for development proposed in the moraine is an attempt to overcome constraints imposed by fragmented jurisdictions in the interim. Rather than the conventional approach of reviewing development applications in isolation, the guidelines require that the stated principles of development must be met before there is any review of technical supporting

information for site-specific development applications.

Currently, co-operative efforts are under way between provincial agencies, municipalities and selected stakeholder groups in the Oak Ridges Moraine to assess cumulative effects through the Oak Ridges Moraine study (ORMS). A technical working committee has been established to guide the planning study and develop a long term strategy for the protection and management of this landform. The technical working committee identified the need for background studies to address such topics as hydrogeology, landform conservation, cumulative effects assessment, long-term monitoring and implementation tools. A citizen's advisory committee has been appointed to help the technical working committee develop the long-term strategy and consult the public on the strategy before it is made final.

7.7 Ecological analysis of Seaton lands

MOEE helped apply the components of an ecosystem approach to an ecological study of the Seaton lands, an area of approximately 2,800 hectares immediately north of the built up portion of the Town of Pickering (HBT AGRA 1994). The study was initiated in 1993 by a Steering Committee led by the Ministry of Housing and with membership from the Ministry of Environment and Energy, Ministry of Natural Resources, Metro Toronto Region Conservation Authority, Ministry of Transportation, and the local and regional municipality.

The purpose of this ecological analysis was to describe the Seaton site and its vicinity as a natural ecosystem in order to permit the assessment of the potential effects of urbanization and the identification of opportunities for environmental protection and enhancement. The baseline environmental information for the analysis was provided in the form of eight technical reports completed in 1991 (Geomatics et al 1991). Much of that environmental information was put into digital form in a Geographic Information System.

The eight technical reports examined individual components of the environment, such as fisheries, woodlots and groundwater. Integration of this baseline information was achieved by applying an ecological perspective to the information in a way that helped understand the functioning of the ecosystems of which Seaton is a part. The description and evaluation of ecosystem functioning was achieved through eleven steps. While these steps are listed sequentially, iteration among them was an important part of the study process.

1. Describe Seaton's ecological context, recognizing that ecosystems occurring within Seaton extend beyond the site boundaries.
2. Provide an overview of the Seaton landscape based on important biological and physical characteristics of the site.
3. Identify and define ecosystem functions to be assessed.

4. Define and apply a set of indicators and criteria for assessing ecosystem functions in some detail.
5. Describe areas of functional ecological importance in Seaton based on the assessment of selected functions.
6. Identify ecological linkages that exist within and beyond the Seaton site;
7. Describe how past and present human activities ("stresses") have affected ecological conditions.
8. Describe the stresses likely to be introduced as a result of urban development.
9. Assess the potential effects of urban development stresses on ecosystem functions to identify the sensitivity of areas to development.
10. Identify opportunities for enhancing ecosystem functions based on preliminary ecosystem objectives.
11. Outline a potential monitoring framework for tracking human activities and changing ecological conditions.

8.0 ANALYSIS

The following matters have been identified as examples of certain of the challenges and opportunities for moving toward an ecosystem approach to land-use planning.

8.1 MOEE's experience with promoting an ecosystem approach

In order to formulate and implement an ecosystem approach, it is essential to draw on experience and knowledge of each of the required components. While not perfect, the previously noted cases provided invaluable experience that can be built on in developing and promoting a comprehensive ecosystem approach.

It requires diverse backgrounds and specific knowledge and skills in a variety of disciplines, some already available within MOEE. At present the Ministry has limited ecological science expertise for understanding and predicting ecosystem structure, function, and cumulative effects. This reinforces the necessity of working in partnership with other agencies, groups and individuals so that a comprehensive approach is possible. For example, various researchers in Ontario's academic community have undertaken ecosystem-based research and are an important potential source of ideas, methodologies, and approaches. This

expertise should be drawn upon to assist MOEE and the province in adopting an ecosystem approach.

Moreover, the federal Department of Environment has a number of important initiatives under way, including the development of ecological indicators, state-of-the-environment monitoring, etc. Both the province and Environment Canada could benefit from exchanging and co-ordinating their efforts in this regard.

In the long term, all stakeholders in the planning process should have an appreciation and basic understanding of the ecosystem approach in order to utilize it in their daily work.

8.2 MOEE's mandate in land-use planning

MOEE participates in the planning process, in order to ensure that areas of concern under its mandate are addressed in the planning and development process. The long-term goal of the Ministry of Environment and Energy's land use program is to ensure that an ecosystem approach to land use planning is adopted in Ontario. The ministry can play an important role in promoting this approach through its involvement in the land-use planning process. However, it is recognized that significant work remains to translate the ecosystem approach into a form that can be promoted through the ministry's participation in the land-use plan review program.

The ministry's primary planning concerns have been municipal servicing and land-use compatibility. In recent years, these have been augmented by an interest in the potential impact on groundwater of privately serviced development and of the soil quality on former industrial or other contaminated sites being considered for redevelopment. It is especially important in the area of water management and protection that ecosystem linkages are made.

The majority of MOEE's policies and guidelines are the product of the historical focus on abatement, point source controls, and reliance on minimum standards to control permitted release of contaminants into the natural environment. Ministry standards and requirements have been formulated largely on the basis of considerations of human health, rather than on maintaining ecosystem integrity. Expanding the program bases and policies to provide for a sound ecological footing would ensure a more sustainable environment over the long term.

8.3 MOEE's participation in long-range planning initiatives

The majority of MOEE's resources dedicated to land-use planning are allocated to reviewing site-specific development proposals, such as subdivision plans and official plan amendments. This orientation is reflected even in the program's name: MOEE's Land Use Plan Review

Program. Detailed reviews of thousands of development proposals have absorbed most of the ministry's resources and has limited the extent of active participation in long-range municipal planning exercises. With the primary role of reviewer of development proposals, the ministry has been placed in reactive mode rather than as a partner in the planning process.

As part of the ministry's recent effort to refocus its involvement in land-use planning, program activities are being redirected to promoting adoption of comprehensive environmental frameworks in all municipal official plans, and supporting broad planning initiatives (e.g. growth management and background studies). The adoption and implementation of comprehensive environmental policies by municipalities should contribute to greater efficiencies in the review process and the ministry will be able to reduce its involvement in detailed reviews and of individual development proposals.

Opportunities to help guide future development exist if MOEE staff participate in background studies undertaken in support of updating official plans, groundwater studies, growth management studies, watershed studies, etc., and if they can make recommendations to municipalities on the environmental policies that should be included in their official plans.

It is crucial that agencies, including MOEE, participate in special efforts -- such as watershed planning initiatives -- to protect or rehabilitate ecosystems. At present the links between the objectives and commitments articulated through these special efforts and the land-use planning process are often tenuous. MOEE, in cooperation with other agencies and municipalities, should ensure that the recommended standards and approaches of these environmental initiatives are incorporated into land-use planning decisions.

8.4 Information requirements in land-use planning

As an agency with responsibility for commenting on development plans, MOEE requires that it first be provided with certain information as part of development applications. Supporting technical reports may be required for addressing such matters as soil quality, hydrogeology, and noise, depending on the particular situation. However, these studies are not obliged to identify ecosystem connections. For example, decisions related to the impact of development on groundwater resources may be made with minimal reference to the potential impact on surface water that may be hydrologically connected to the groundwater being affected.

Recognition must be given to the value of resource-related information, mapping, and data bases, and the value of developing strategies for protecting such sensitive areas as groundwater recharge and discharge areas. The information currently provided for site-specific planning applications is not incorporated into a common data base, nor is it integrated into an information network. Thus, the information provided is not readily

available or in a retrievable format for future access by MOEE staff or other interested parties.

Networks are required to monitor ecosystem health and integrity; existing efforts by MOEE, other agencies, and municipalities must be examined and assessed for the way they contribute to implementation of an ecosystem approach. The cumulative effects monitoring project for the Niagara Escarpment has potential as the prototype for such future projects. MOEE, co-operation with other agencies such as MNR and MCCR, should also assess how it can best support development of integrated information networks, including Geographic Information Systems, that are accessible to all stakeholders.

8.5 Cumulative effects assessment

Many of the tools already exist that would comprise a successful cumulative environmental effects assessment methodology: impact assessment, modelling, matrices, mapping and overlays, risk assessment, trend analysis, cluster analysis, etc. A better understanding of the cause-effect relationships that result in cumulative effects will lead to more agreement on methods for predicting cumulative effects. Cumulative effects assessments must be undertaken as part of a strategic planning process that is based on an, ecosystem approach involving identification of ecosystem objectives, boundaries, information, and monitoring. Progress will only be made toward developing a cumulative environmental effects methodology by initiating an ecosystem approach and applying existing evaluation techniques.

As we move toward an ecosystem approach, further research is required so we can properly understand the cause-effect relationships that characterize the pathways and the functional processes of ecosystems and that lead to cumulative environmental effects. The ministry's research funding program could be one means of supporting ecosystem-based approaches to planning and regulation, including cumulative effects assessment.

8.6 Ecosystem boundaries and land-use planning

The land-use planning process itself reflects activities in a patchwork of municipalities and provincial agencies with restricted jurisdictions, as well as geographic boundaries that are not based on ecological units.⁵ Without mechanisms and formal means for co-ordinated planning across political boundaries, planning decisions will continue to be made without reference to an ecosystem-based context.

⁵ An exception to the rule is conservation authorities in Ontario whose geographic focus is watersheds.

8.7 Need for provincial ecosystem approach

A common ecosystem approach must be clearly spelled out if it is to provide clear guidance and direction to municipalities. For example, agreement among provincial agencies and their municipal counterparts is required on:

- criteria and methods for implementation;
- roles and responsibilities for defining ecosystem objectives for ecological units and translating them into the land-use planning process;
- information requirements and the development of information management systems; and monitoring ecosystem health over time.

A provincial approach would also facilitate integration of diverse and sometimes competing mandates of provincial agencies and define the ecological "bottom line" as a context for deliberating options. Leadership for developing this approach, soundly and defensibly, must come from the ministries with the greatest environmental responsibilities and the broadest knowledge and experience: MOEE and MNR. However clearly all provincial ministries and agencies must work together to reach agreement on a common ecosystem perspective.

Leading municipalities are breaking new ground in the area of ecosystem planning. These efforts should be reinforced and utilized, where appropriate, as the building blocks for a concerted effort at promoting the implementation of an ecosystem approach to land-use planning.

8.8 Making broader connections

This kind of land-use planning will not succeed in isolation: ecosystem objectives must be applied, over time, to all activities and programs that have an impact on the environment. It means examining our industrial strategies, agricultural programs, etc. for their potential to contribute to our ability to achieve and maintain healthy ecosystems. At the same time, implementing an ecosystem approach in land-use planning will be a significant step forward.

9.0 REFERENCES

- Bardecki, Michael J. 1988 Coping with Environmental Impacts: An Assessment of Legislative and Administrative Mechanisms, from Proceedings of the 1988 Meeting of the International Association for Impact Assessment, Brisbane, Australia.
- Bastedo, J.D., J.G. Nelson, and J.B. Theberge 1984 "Ecological Approach to Resource Survey and Planning for Environmentally Significant Areas: The ABC Method", Environmental Management 8/2: 125-134.
- Cada, Glenn F., and Carolyn T. Hunsaker 1990 "Cumulative Impacts of Hydropower Development: Reaching a Watershed in Impact Assessment", The Environmental Professional 12:2-8.
- Canadian Council of Ministers of the Environment (CCME) September 1991 The Development and Use of Ecosystem Objectives, from a Summary of Workshop Proceedings on Ecosystem Objectives, Ottawa, Canadian Council of Ministers of the Environment.
- Canadian Environmental Assessment Research Council (CEARC) 1988 The Assessment of Cumulative Effects: A Research Prospectus, Government of Canada, Federal Environmental Review Office, 13th Floor, Fontaine Building, 200 Sacre-Coeur Blvd., Hull, Quebec.
- CEARC 1986 Cumulative Environmental Effects: A Binational Perspective, Government of Canada, Hull, Quebec.
- Commission on Planning and Development Reform in Ontario April 1992 New Planning News 2:2, Government of Ontario. Available from the Commission on Planning and Development Reform in Ontario, 180 Dundas St. W., 22nd Floor, Toronto, Ontario.
- Conservation Council of Ontario (CCO) 1986 Towards a Conservation Strategy for Ontario: An Assessment of Conservation and Development in Ontario, CCO, Suite 202, 74 Victoria Street, Toronto, Ontario.
- Dangermond, J.C., and C. Freedman 1986 Introduction to Geographic Information System Technology, workshop paper. Environmental Systems Research Institute, 380 New York St., Redlands, California.
- Davies, Katherine 1991a Assessing Cumulative Environmental Effects: An Introduction, prepared for the Ontario Hydro Workshop on the Moose River Basin Plan Assessment in Timmins. Ontario Hydro.

- Davies, Katherine 1991b Towards Ecosystem-Based Planning: A Perspective on Cumulative Environmental Effects, Working Paper No. 8, Royal Commission on the Future of the Toronto Waterfront and Environment Canada. Available from the Royal Commission on the Future of the Toronto Waterfront, 207 Queen's Quay, P.O. Box 4111, Station A, Toronto, Ontario.
- Dorney, Robert S. 1989 The Professional Practice of Environmental Management. Linday Dorney (ed.), New York: Springer-Verlag.
- Environmental Assessment Advisory Committee (EAAC) 1990a Report #41(1) Sydenham Mills Subdivision, February 14.
- EAAC 1990b Report # 41(2) Grey County Planning Approvals, December 28. EAAC 1989 Report # 38 Ganaraska Planning and Approvals Process, November 15. EAAC 1988 Report # 33 Etobicoke Motel Strip, November 10.
- Freedman, B , N.L. Shackell, and C.A. Staicer January 1992 A Framework for a National Environmental Monitoring Program, presentation to Ministry of the Environment staff on February 21, 1992.
- Geomatics International Inc., Beak Consultants Limited, Aquafor Engineering Limited 1991 Seaton Lands Environmental Hazard Studies, (8 Volumes) prepared for Seaton Interim Planning Team, Ontario Ministry of Housing.
- Gosselink, J.G., and L.C. Lee 1987 Cumulative Impact Assessment in Bottomland Hardwood Forests, Center for Wetland Resources, Louisiana State University, Baton Rouge, LSU-CEI-86- 90.
- Great Lakes Advisory Board July 1978 The Ecosystem Approach: Scope and Implications of an Ecosystem Approach to Transboundary Problems in the Great Lakes Basin, Special Report to the International Joint Commission, Windsor, Ontario.
- Greater Toronto Area Office March 1992 GTA 2021 - The Challenge of our Future: A Working Document. Government of Ontario, Greater Toronto Area Office, 5 Park Home Ave., Suite 210, North York, Ontario.
- HBT AGRA Ltd. 1994 Seaton Lands as a Natural Ecosystem, prepared for Seaton Interim Planning Team, Ontario Ministry of Housing.
- Horak, G.E., E.C. Vluchos, and E.W. Cline 1983 "Methodological Guidelines for Improved Institutional Analysis in Water Resources Planning", Water Resources Research 20/3: 323-334.

- Hough, Michael 1990 Out of Place: Restoring Identity to the Regional Landscape, London: Yale University Press.
- Hubbard, Pamela M. 1990 Cumulative Effects Assessment and Regional Planning in Ontario, prepared for Canadian Environmental Assessment Research Council, Federal Environmental Assessment Office, Hull, Quebec.
- Imhof, Jack G., R. John Planck, Fred M. Johnson, Larry C. Halyk 1991 Watershed Urbanization and Managing Stream Habitat for Fish, 56th North American Wildlife and Natural Resources Conference.
- Johnson, Carol A., N.E. Detenbeck, J.P. Bonde, and G.J. Niemi 1988 "Geographic Information Systems for Cumulative Impact Assessment", Photogrammetric Engineering and Remote Sensing 54/11:1609-1615.
- Karr, James 1991 "Biological Integrity: A Long-Neglected Aspect of Water Resource Management", Ecological Applications 1:1.
- Odum, Eugene 1971 Fundamentals of Ecology Philadelphia: W.B. Saunders Co.
- Ontario Ministry of Environment and Energy 1994 Monitoring Cumulative Environmental Effects In The Niagara Escarpment Plan Area, Report prepared by a Team of Consultants headed by MACVIRO Consultants Inc. for the Ministry of Environment and Energy.
- Ontario Ministry of Environment and Energy and Ministry of Natural Resources 1993 Set of three documents entitled Watershed Management On A Watershed Basis: Implementing An Ecosystem Approach; Subwatershed Planning; and Incorporating Water Management Objectives into Municipal Planning Documents, Government of Ontario.
- Ontario Round Table on Environment and Economy 1990 Challenge Paper, Government of Ontario, Ontario Round Table Office, 790 Bay Street, Suite 1003, Toronto, Ontario.
- Ontario Round Table on Environment and Economy 1991 Sectoral Task Force Draft Reports: Urban Development and Commerce, Forestry, Agriculture and Food. Energy and Minerals, Manufacturing, Transportation, Government of Ontario.
- Premier's Council on Health, Well-Being and Social Justice, Working Group 3 July 1991 Objectives and Targets for Ensuring a Safe, High Quality Physical Environment, Government of Ontario. Premier's Council on Health, Well-being and Social Justice, 777 Bay St., 17th Floor, Toronto, Ontario.

- Preston, Eric M., and Barbara L. Bedford 1988 "Evaluating Cumulative Effects on Wetland Functions: A Conceptual Overview and Generic Framework", Environmental Management 12/5:565-583.
- Regier, Henry A. 1990 Indicators of Ecosystem Integrity, paper for the International Symposium on Ecological Indicators, Fort Lauderdale, Florida. Institute for Environmental Studies, University of Toronto.
- Royal Commission on the Future of the Toronto Waterfront 1992 Regeneration - Toronto's Waterfront and the Sustainable City: Final Report ISBN, Minister of Supply and Services, Government of Canada.
- _____ April 1991 East Bayfront and Port Industrial Area: Pathways: Towards an Ecosystem Approach, Minister of Supply and Services, Government of Canada.
- _____ August 1990 Watershed: Interim Report, Minister of Supply and Services, Government of Canada. Available from the Royal Commission on the Future of the Toronto Waterfront, 207 Queen's Quay, P.O. Box 4111, Station A, Toronto, Ontario.
- _____ March 1990 A Green Strategy for the Greater Toronto Waterfront: Background and Issues, Minister of Supply and Services, Government of Canada.
- Schaeffer, David J., Edwin E. Herricks, and Harold W. Kerster 1988 "Ecosystem Health: I. Measuring Ecosystem Health", Environmental Management 12/4:445-455.
- Science Advisory Board 1990 Reducing Risk: Setting Priorities and Strategies for Environmental Protection, report to W.K. Reilly, Administrator, U.S. Environmental Protection Agency. September.
- Sonntag, N.G., R.R. Everitt, L.P. Rattie, D.L. Colnett, C.P. Wolf, J.C. Truett, A.H.J. Dorsey, and C.S. Holling 1987 Cumulative Effects Assessment: A Context for Further Research and Development, Canadian Environmental Assessment Research Council, Government of Canada, Federal Environmental Assessment Office, Hull, Quebec.
- Sparrow, M.K. 1991 "From Data Warehouse to Information Craft Shop: The Changing Shape of Information Support for Environmental Protection", Environment International 18:3-9.
- Stakihiv, Eugene Z. 1988 "An Evaluation Paradigm for Cumulative Impact Analysis", Environmental Management, 12/5:725-748.

Toner, William 1988 "Environmental Land-Use Planning", The Practice of Local Government Planning (second edition), Frank S. So and Judith Getzels (eds.), New York: International City Management Association.

Woodley, Stephen January 1991 Monitoring for Ecosystem Integrity in Canadian National Parks, Canadian Parks Service, National Parks Documentation Centre, Hull, Quebec.