INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

**IMPLEMENTING CUMULATIVE EFFECTS ASSESSMENT:
A FRAMEWORK AND APPROACH FOR
CANADA'S NATIONAL PARKS**

by Louise Kingsley

A thesis
presented to the
University of Carleton

in partial fulfilment of the requirements
for the degree of

Masters of Arts
in Geography

December, 1997

© Louise Kingsley, 1997

National Library
of Canada

Acquisitions and
Bibliographic Services

395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque nationale
du Canada

Acquisitions et
services bibliographiques

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

Our file Notre référence

The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-26959-0

Canada

The undersigned recommend to the Faculty of Graduate Studies
and Research acceptance of the thesis

**“IMPLEMENTING CUMULATIVE EFFECTS ASSESSMENT:
A FRAMEWORK AND APPROACH FOR
CANADA’S NATIONAL PARKS”**

submitted by Louise Kingsley, B.Sc.,
in partial fulfilment of the requirements for
the degree of Masters of Arts

Thesis supervisor

Chair, Department of Geography

*Carleton University
December 5, 1997*

ABSTRACT

This thesis presents a conceptual framework and approach for the assessment of cumulative environmental effects within Parks Canada. The concept uses an ecosystem approach and is based on four principles: (1) environmental assessments must be tiered; (2) the critical focus for CEA is the ecosystem management level; (3) CEA involves analysing trends and thresholds through the use of key components and indicators; and (4) uncertainty is unavoidable and must be minimized through precaution, integrated monitoring and feedback.

The conceptual framework is based on a cause-effect analysis model. Overall effects of a proposal are evaluated to determine whether changes brought about by the proposal under review, in combination with other stressors, will move the system closer to or away from ecological or commemorative integrity. A step-by-step approach is provided to accomplish this. Three test cases demonstrate that the framework and approach are useful and effective tools for assessing cumulative effects.

ACKNOWLEDGEMENTS

I would like to thank Parks Canada for providing me with the opportunity to undertake this work. A project such as this one cannot successfully be undertaken in isolation, and I am indebted to the many who contributed advice, shared ideas, participated in discussions, and provided support, as well as all those who participated in the workshops, case studies and tests. I particularly wish to extend my heartfelt thanks to the following people:

Staff of the Natural Resources Branch at Parks Canada were especially helpful in the course of this assignment. Luce Charron contributed invaluable support and encouragement throughout my work. Luce not only provided considerable input into the method and CEA framework, but also reviewed and commented on the thesis. André Savoie lent support throughout the assignment and provided helpful comments on the framework. Ila Smith reviewed several drafts of the approach and provided many helpful and practical suggestions.

Mike Smith, my thesis advisor, provided a forum for discussion, food for thought, helpful advice and comments; his encouragement was much appreciated. Mike Brklacich and Patrice LeBlanc reviewed this work and provided advice and comments.

Sarah Kalff undertook the Louisbourg case study, shared ideas and provided valuable input into the framework. Denis Veillette provided helpful advice and input into the framework, and was a driving force behind the test cases at La Mauricie National Park. Jean-François Villemure organized the La Mauricie workshops and actively participated in two test cases. Monique Béland worked on the hiking trail test case and provided comments and suggestions on the overall approach. Jim Norris was instrumental in setting up and providing input into the Trent-Severn test case. Derek Coleman and Shawn Gibbons worked on the Trent Severn test case and helped scope issues and concerns. Bruce Leeson applied the approach in the course of his work and provided me with advice and encouragement. Many others participated in the test cases, sent in examples or suggestions, and provided comments on various drafts of the approach.

Judy Kingsley reviewed the text and curbed my overcreative spelling.

Last but certainly not least, my husband Julien Cota provided tremendous encouragement and support. I could not have completed this work without him.

Errors and omissions are mine alone.

Note: The material reviewed in this thesis has also served to develop a Parks Canada manual, the *"Guide to Environmental Assessments: Assessing Cumulative Effects"* (Kingsley, 1997)

TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENT	v
LIST OF TABLES	ix
LIST OF FIGURES	ix

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Purpose and Objectives of Thesis	1
1.2 Background	2
1.2.1 Towards a broader perspective of environmental assessment	2
1.2.2 Federal legislative context	4
1.2.3 Opportunities within Parks Canada for assessing cumulative effects	5
1.2.4 Current state of heritage areas	8
1.3 Method	11
1.3.1 Developing the framework	11
1.3.2 Testing the framework	12
1.3.3 Report organization	13

CHAPTER 2: THE DEBATES OVER CEA: TOWARDS A WORKING UNDERSTANDING OF CUMULATIVE EFFECTS

2.1 What is meant by cumulative effects?	16
2.1.1 Definitions	16
2.1.2 Attributes of cumulative effects	17
2.1.3 Challenges in assessing cumulative effects	20
2.2 Positioning CEA in the decision making hierarchy	21
2.2.1 The “project-versus planning” debate	21
2.2.2 Applying CEA at strategic levels	23
2.2.3 Applying CEA at project levels	28
2.2.4 The concept of tiering	29
2.3 Adopting a broader perspective	33
2.3.1 The importance of scales	33
2.3.2 Scale-dependent variables	34
2.3.3 Matching the level of decision to the scale of the problem	36
2.4 Defining thresholds and limits	39
2.4.1 The notion of thresholds and carrying capacity	39
2.4.2 Types of thresholds for CEA	40
2.5 Science, values and uncertainty	43
2.5.1 The role of science in CEA	43

2.5.2	Uncertainties in predicting and modeling cumulative effects	44
2.5.3	Uncertainties in determining values and responsibilities	47
2.6	Generating principles of CEA	48
2.6.1	Principle 1: Environmental assessments should be tiered	48
2.6.2	Principle 2: The critical focus for CEA is the ecosystem management level	49
2.6.3	Principle 3: Analyse trends and thresholds through key components and indicators	51
2.6.4	Principle 4: Uncertainty must be minimized through a precautionary approach and integrated monitoring	52
2.7	Chapter conclusions and next steps	53

CHAPTER THREE: TOWARDS A CONCEPTUAL FRAMEWORK FOR CEA

3.1	Direction provided by the case study	54
3.1.1	Selecting a major case study	54
3.1.2	General approach and results	55
3.1.3	Lessons learned from the case study	57
3.2.	Organizing concepts	58
3.2.1	Sustainable development as a first principle for CEA	58
3.2.2	CEA as an ecosystem approach to environmental assessment	60
3.2.3	Integrity as an endpoint for CEA	61
3.2.4	Using indicators in support of CEA	63
3.3.	The cause-effect model for CEA	66
3.3.1	Exploring the cause-effect model	66
3.3.2	Evaluating the consequences of cumulative change	69
3.4	A conceptual framework for assessing cumulative effects	71
3.4.1	Building blocks	71
3.4.2	Framework flow	71
3.4.3	Developing step-by-step guidance	74
3.5	Chapter conclusions and next steps	75

CHAPTER FOUR: INTERPRETING THE FRAMEWORK: A STEP-BY-STEP GUIDE

4.1.	Scoping	77
4.1.1	Scoping the policy context	79
4.1.2	Scoping issues and concerns	79
4.1.3	Identifying key environmental components	81
4.1.4	Determining the appropriate scale	85
4.2.	Analysis	92
4.2.1	Identifying the sources of stress	93
4.2.2	Identifying relevant pathways	97

4.2.3 Identifying the response of the environment	101
4.2.4 Predicting how the proposal changes the existing context	104
4.2.5 Identifying mitigation	106
4.3. Evaluation	107
4.3.1 Using objectives, targets, and thresholds	108
4.3.2 Evaluating the significance of residual impacts	112
4.3.3 Dealing with uncertainties	113
4.4 Follow-up, feedback and documentation	117
4.4.1 Surveillance and follow-up requirements	118
4.4.2 Feedback requirements	120
4.4.3 Documentation	122
4.5 Summary of steps	124
4.6 Chapter conclusions and next steps	126
 CHAPTER 5: TESTING THE APPROACH	
5.1 Testing the approach in La Mauricie National Park	127
5.1.1 Rationale	127
5.1.2 Introduction to La Mauricie National Park	128
5.1.3 Visitor use and facilities	130
5.2 First test case: proposed long-distance hiking trail in La Mauricie National Park	132
5.2.1 Project proposal: the long-distance hiking trail	132
5.2.2 Summary of initial screening	134
5.2.3 General approach and scoping cumulative effects	136
5.2.4 Identifying contributing stressors	138
5.2.5 Analysis of cumulative effects	141
5.2.6 Evaluation and recommendations	142
5.2.7 Evaluating the test case	144
5.3 Testing the approach on a park management plan	147
5.3.1 Initial considerations and approach	147
5.3.2 The nature of the management plan	148
5.3.3 Strategic directions of the management plan	151
5.3.4 Scoping first principles	154
5.3.5 Scoping boundaries and key issues	157
5.3.6 Preliminary analysis	158
5.3.7 Preliminary recommendations	163
5.3.8 Evaluating the test case	164
5.4 Testing the approach for multiple small projects along the Trent-Severn Waterway	167
5.4.1 Rationale	167
5.4.2 Introduction to the Trent-Severn Waterway	168
5.4.3 Approach	170

5.4.4 Results of the scoping	171
5.4.5 Analysis based on sources, pathways and consequences	172
5.4.6 Evaluation and recommendations	176
5.4.7 Evaluating the test case	178
5.5 Chapter conclusions and next steps	180

CHAPTER SIX: CONCLUSIONS

6.1 Initial considerations	181
6.1.1 Is the approach necessary?	181
6.1.2 is the approach solid?	182
6.2 Conclusions from the test cases	183
6.2.1 Usefulness of the approach	183
6.2.2 Effectiveness of the approach	186
6.2.3 Support for first principles	189
6.3 Lessons learned	190
6.4 Looking to the future	193

REFERENCES	195
-------------------	-----

CHAPTER ONE

INTRODUCTION AND BACKGROUND

1.1 PURPOSE AND OBJECTIVES OF THESIS

The concept of cumulative effects assessment, or CEA, has attracted a tremendous amount of attention since the 1980s. There is little disagreement over the importance and benefits of assessing cumulative environmental effects, and of integrating this information into the decision-making process. However, virtually everything else about CEA has sparked debate. The literature includes open speculations as to whether it is possible to assess cumulative effects, and abounds with discussions of how to define, organize and implement the concept. There is currently no widely-accepted conceptual framework for cumulative effects assessment, and the search for a broadly applicable method continues.

This thesis proposes that cumulative effects assessment is both necessary and possible, and can be implemented in the context of environmental assessment (EA). The objective of this study is to develop, test and document a comprehensive conceptual framework and a practical approach for implementing cumulative effects assessment within Parks Canada.

It is beyond the scope of this thesis to examine aspects of environmental assessment that do not change as a result of the requirement to consider cumulative effects. For example, public consultation is a fundamental requirement of EA that is not discussed in detail in this report.

This is in no way intended to minimize its importance, but to maintain the focus on those aspects of EA that must evolve in order to accommodate CEA.

1.2 BACKGROUND

1.2.1 Towards a broader perspective of environmental assessment¹

Environmental assessment (EA) can be defined as a systematic, participatory process that identifies and predicts the potential environmental impacts of a project or activity before irrevocable decisions are made. EA, developed in response to a perceived bias in conventional decision making which favored short-term economic goals at the expense of the environment, is intended to provide decision makers with a better understanding of the environmental implications of their choices and alternatives. Initially, environmental assessment reports were mainly descriptive documents that made little use of predictive science (Beanlands and Duinker, 1983; Culhane et al., 1987). The practice of environmental assessment has evolved over the past 25 years, as the perception of environmental issues has changed.

¹

While some have distinguished between environmental impact assessment (EIA) and environmental assessment (EA), the terms are used interchangeably in this report, to avoid discussion over semantics. In general, terms used in this thesis are defined as they are introduced in the text.

The popularization of the concept of sustainable development brought to the forefront of environmental discourse the question of long-term survival, the rights of future generations, and the importance of equitable sharing of resources (WCED, 1987; IUCN/UNEP/WWF, 1991). Links between the health of current and future generations and the health of the environment highlighted the importance of respecting the planet's finite carrying capacity: thus the right of humans to a healthful environment engendered the responsibility to protect that environment (IUCN/UNEP/WWF, 1991).

There is little doubt that meeting that responsibility presents a challenge. The 1992 State of the World report described the 1990s as the "decisive decade for the planet and its inhabitants", citing rapidly thinning ozone levels, the daily loss of 140 species, a 26% rise in atmospheric levels of carbon dioxide, record warming trends, the yearly loss of 17 million hectares of forests, and an annual population growth of 92 million people (Postel, 1992). Such trends are all global in nature, and stem from the cumulative interactions of numerous activities.

It is widely recognized that individually insignificant activities can cumulatively contribute to major environmental concerns at the regional and global levels. Conventional reductionist disciplines and political jurisdictions have not effectively dealt with such issues. However, environmental assessment was recognized as a key tool in implementing sustainable development (NTFEE, 1987; WCED, 1987).

Concern for cumulative effects was identified in environmental assessments as early as the 1970s, especially in northern development projects. In 1976 McTaggart-Cowan identified the problem of “destruction by insignificant increments” in the MacKenzie Delta (McTaggart-Cowan, 1976), and the Berger inquiry of 1977 expressed concern over cumulative impacts of developments in the Western Arctic (Berger, 1977). Successive panel reviews increasingly requested information on cumulative effects. While the assessment of cumulative effects within EAs is still far from common practice and far from rigorous (Elkin and Smith, 1987; Beanlands, 1992; McCold and Holman, 1995), it has come to be regarded as part of the “second generation” of EAs (Sadler, 1986).

An International Study on the Effectiveness of Environmental Assessment suggests a move towards a broader application of EA (Doyle and Sadler 1996). The study concluded that EA is “more important than ever”, and suggests that efforts must be directed at developing guidelines, principles and codes of good practice, with cumulative effects and assessing large-scale changes identified as priorities (Sadler, 1996).

1.2.2 Federal legislative context

In Canada, a requirement for the assessment of cumulative effects is established in federal legislation. The *Canadian Environmental Assessment Act*, (R.S.C. 1992, c.S 16.1), promulgated in 1995, established for the first time a legal requirement to assess cumulative

effects of proposed projects:

“Every screening or comprehensive study of a project and every mediation or assessment by a panel review shall include consideration of the following factors:

(a) ...any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;

(b) the significance of the effects referred to in paragraph (a)”.

A 1993 Cabinet Directive, the *Environmental Assessment Process for Policy and Program Proposals*, established a non-legislated process for the assessment of federal policy and program initiatives (FEARO, 1993b); guidance documents prepared for this process indicate its potential to address cumulative effects.

1.2.3 Opportunities within Parks Canada for assessing cumulative effects

As a manager of federal heritage lands, Parks Canada is in an advantageous position for undertaking the assessment of cumulative effects. Parks Canada's mandate is essentially environmental. The purpose of Parks Canada is described in its main policy document:

“To fulfill national and international responsibilities in mandated areas of heritage recognition and conservation; and to commemorate, protect and present, both directly and indirectly, places which are significant examples of Canada's cultural and natural heritage in ways that encourage public understanding, appreciation and enjoyment of this heritage, while ensuring long-term ecological and commemorative integrity” (Department of Canadian Heritage, 1994a).

Within this context, Parks Canada is committed to the protection of national parks, national

historic sites, historic canals, Canadian heritage rivers, federal heritage buildings, and heritage railway stations. A number of laws and regulations have been developed to assist Parks Canada in carrying out its goals. Chief among these is the *National Parks Act*, which includes a commitment to future generations set out in a dedication clause (R.S.C. 1988, c. S. 4):

“The National Parks of Canada are hereby dedicated to the people of Canada for their benefit, education and enjoyment ... and the National Parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations.”

Parks Canada has adopted an ecosystem management approach which involves a commitment to protection of the integrity of heritage areas (Department of Canadian Heritage, 1994a). A 1988 amendment to the *National Parks Act* incorporated the goal of ecological integrity into legislation, recognizing it as the first priority in national parks. Definitions of ecological and commemorative integrity have been developed and refer to conditions where the ecosystem or resources for which a site is being commemorated are not impaired or threatened and the heritage values are being protected (Parks Canada, 1994). Integrity statements are being developed for individual national parks and national historic sites to provide a management accountability framework for preserving their integrity.

Resource management and planning processes are in place for the collection, analysis and interpretation of data within heritage areas, thus providing necessary integrated data bases and background information. For example, within national parks, all activities directed

towards the maintenance or modification of the biotic or abiotic resources are guided by a framework called the “*Natural Resources Management Process*”, (Natural Resources Branch, 1992). The process describes a series of interlinked steps to collect, analyze and interpret baseline information and integrate it into relevant management documents such as the park management plan, the ecosystem conservation plan and plans for the management of specific resources.

The management of visitor activities is also guided by a framework, the Visitors Activities Management Process (VAMP), which describes management requirements for visitors at each stage of the park management process (Environment Canada, 1988).

The *National Parks Act* requires that a management plan be prepared and tabled in Parliament within five years after the proclamation of a park. A review of the management plan is required every five years and any amendments must be tabled in Parliament. Public participation at the national, regional and local levels is required where appropriate. The Minister is also required to report regularly to Parliament on the state of the parks and on the status of the establishment of new parks.

The environmental assessment process within Parks Canada is well established and operational. Parks Canada is committed to undertaking environmental assessments in an exemplary manner, at all levels of the decision-making process, including projects, plans and

policies. Departmental procedures also require that proposals which are likely to adversely affect heritage areas must be subject to environmental assessment even in the absence of a legal trigger under the *Canadian Environmental Assessment Act* (Department of Canadian Heritage, 1996).

For these reasons, Parks Canada is in a strong position to implement cumulative effects assessment. The development of a CEA framework would allow Parks Canada to meet, not only its legal obligations defined under the *Canadian Environmental Assessment Act*, but also its further obligations stemming from *Parks Canada Guiding Principles and Operational Policies* and the *National Parks Act*.

1.2.4 Current state of heritage areas

Canadians take great pride in their heritage areas, which they generally view as healthy and pristine. However, many impacts of concern may not be immediately visible or apparent.

The 1990 State of the Parks Report (Environment Canada, 1990) represents the first attempt to assess the condition of Canadian heritage areas, and its preparation raised many questions regarding appropriate standards for rating the health of these areas. The report concludes that: "*Canada's National Parks, National Historic Sites and Historic Canal Systems are, by the most available measure, in a satisfactory state*". The document reports favorably on the

growth and evolution of the system of heritage areas, but notes that it is not without problems:

“Like all lands and buildings, they are threatened by global phenomena; climate change and acid rain are perhaps the two most frequently cited. There is always the threat that too much popularity will translate to overuse and deterioration of the resources; new management techniques are dealing with this, but more are needed.” (Environment Canada, 1990).

As shown in Table 1, national parks are subject to a wide range of stressors, many of which are increasing in effect (Savoie and Woodley, 1993). In some cases, problems have been inherited from previous management techniques that were not sensitive to ecological processes. For example, in several parks native fish species were removed and sport fish were introduced in an effort to promote sport fishing. Fire suppression led to widespread changes in natural processes. Many heritage areas are subject to high levels of use and multiple development which threaten the ecosystem integrity. For example, the Task Force mandated with investigating solutions to growing threats to the integrity of the Banff Bow Valley noted that:

“Banff National Parks, with two communities, three commercial ski hills, a 27-hole golf course, a four-lane divided Trans Canada Highway, and a rail corridor... is the product of Canada’s century-long search to define a national park and the compromises that were made along the way.” (Page et al., 1996a).

National parks are not the only heritage areas subject to stress. External factors can affect resources within national historic sites; in some cases high levels of use and erosion can threaten both cultural and natural resources. For example, the Chilkoot Trail, made famous in North America’s last gold rush when thousands of stampederers followed it to the Yukon

gold fields, is one of the only national historic sites where recreational users are encouraged to hike around historic features. Indiscriminate camping and foot traffic over delicate terraces and historic retaining walls was leading to the incremental destruction of both natural and cultural resources (Hems, 1996).

Table 1: Sources of Stress in Canadian National Parks (from Savoie and Woodley, 1993a)	
1. Tourism infrastructure; 2. Exotic vegetation; 3. Service corridors; 4. Logging activities; 5. Agriculture; 6. Acid deposition; 7. Urbanization; 8. Dams; 9. Exotic wildlife (mammals); 10. Petro-chemicals; 11. Pesticides 12. Management methods; 13 Heavy metals; 14. Exotic fish;	15. Mining activities; 16. Exotic invertebrates; 17. Human activities; 18. Climate change; 19. Exotic birds; 20. Solid waste; 21. Poaching; 22 Collisions (wildlife and vehicles); 23. Commercial fishing; 24. Sport fishing; 25. Exotic micro-organisms; 26. Ozone; 27. Sport hunting; 28. Liquid waste (sewage).

It is apparent that the cumulative effects of past and current human actions on a local, regional and global scale, threaten the ecological and commemorative integrity of Canadian heritage areas, and must be considered in current and future decision making. For this reason, the development of a broadly applicable, practical framework and approach for the assessment of cumulative effects is viewed as critical.

1.3 METHOD

1.3.1 Developing the framework

The CEA framework was developed through a process which involved a combination of literature review, review of current practice, consultations, and ongoing validation of concepts through iterative case studies.

Background information was obtained through an extensive literature review covering both the theory and practice of environmental assessment, cumulative effects assessment, and related fields such as sustainable development and ecosystem management. A number of environmental assessments were examined; these ranged from small project screening reports to panel reviews and plan assessments.

The proposed framework and approach were reported in a series of sequential drafts that were circulated and modified as the work progressed. Iterative case studies were carried out in the initial development phases of the framework, to provide ongoing feedback and to obtain practical input into the early stages of the approach. The first and most important case study involved the Fortress of Louisbourg National Historic Site, where a cumulative effects assessment was undertaken based on an early draft approach. Ongoing work on cumulative effects monitoring at the Bruce Peninsula National Park provided a second case study.

Results of the case studies were incorporated into subsequent drafts of the CEA framework.

Seven workshops were held in various locations throughout Canada as the work on this project progressed. Workshops were held to define requirements for a CEA framework and overall approach, to identify priorities and concerns, to validate findings and to provide input to refine draft approaches. Additional consultations were held with Parks Canada staff, environmental assessment practitioners, and experts in related fields such as heritage conservation and ecosystem management.

A practitioner's guide, for use within Parks Canada, was prepared concurrently with this thesis (Kingsley, 1997). A final draft of the Guide was circulated extensively through Parks Canada and was submitted for peer review to members of the *Cumulative Effects Assessment Working Group* chaired by the *Canadian Environmental Assessment Agency*. Comments received from these sources were integrated into the final version of the framework.

1.3.2 Testing the framework

Evaluation criteria were developed to provide a context for testing the conceptual framework and approach for CEA. Criteria were based on accepted attributes of the effectiveness of EA systems as defined in the *International Study of the Effectiveness of Environmental Assessment* (Doyle and Sadler, 1996). Each of the ten effectiveness attributes were applied

to the specific context of a CEA framework: the resulting evaluation criteria are described in Table 2.

Because the criteria included scope of application, it was determined that several scenarios would be required to best evaluate the applicability of the proposed framework within the range of circumstances that can be found at Parks Canada. The major case study, undertaken at the Fortress of Louisbourg National Historic Site, provided insight on the applicability of the framework in the context of cultural heritage resources. Three test cases were also undertaken. A first test involved a “typical” project within Parks Canada, while a second test investigated the environmental assessment of a park management plan. The final test focused on small, repetitive projects with individually insignificant impacts which could take on collective importance.

1.3.3 Report organization

The organization of this report reflects the general sequence of work undertaken to develop the framework and approach, and the logical order of steps required to assess cumulative effects. It must be recognized, however, that it is very challenging to present the concept of cumulative effects in a linear sequence. Environmental assessment itself is an iterative process, and most components of cumulative effects assessment are highly interrelated. This may not present a problem in practice, since the need for cross-checking and feedback is

Table 2

Development of evaluation criteria based on accepted attributes of effective EA systems

Attributes of EA effectiveness (Doyle and Sadler, 1996)	Corresponding criteria for CEA framework and approach
1. Establish a clear purpose and explicit goals/direction.	1. <i>Clarity of purpose:</i> provide a clear understanding of the concept and provide clear direction so that the process is applicable by Parks Canada staff or external consultants.
2. Incorporate long-term and overall perspective, including a broader definition of environment and cumulative effects.	2. <i>Incorporation of broad perspective:</i> provide information on effects resulting from the "bigger picture", beyond that which is provided by the traditional project-specific approach.
3. Provide a broad scope of application, including large and small projects, programs, plans and policies (through strategic EA).	3. <i>Broad scope of application:</i> accommodate a range of circumstances such as large and small proposals including projects, plans, programmes and policies within national parks, national historic sites and heritage canals.
4. Be responsive to public/stakeholder involvement.	4. <i>Stakeholder involvement:</i> incorporate input from stakeholders.
5. Provide for interjurisdictional harmonization.	5. <i>Interjurisdictional:</i> provide for the broader ecosystem perspective and inter-jurisdictional goals and objectives.
6. Monitor results and respond to findings.	6. <i>Monitoring and feedback:</i> incorporate follow-up and provide for feedback mechanisms.
7. Ensure certainty of decision-making through fixed time lines and commitments.	7. <i>Timely input into decision making:</i> applicable in the early stages of decision making, so that potential impacts can be predicted in advance, and information used to improve the planning of the proposal under review.
8. Adapt to change as a living process to incorporate new methodologies, technologies, approaches, public expectations of involvement, societal values, etc.	8. <i>Flexibility and adaptability:</i> incorporate new techniques and methods as required and available.
9. Provide value for money.	9. <i>Cost-effectiveness:</i> use available information and processes where possible to minimize additional costs.
10. Achieve environmental sustainability.	10. <i>Insight for long-term direction:</i> provide a vision and direction for the long-term perspective to support environmental sustainability.

often apparent as the work progresses. The complexities arise in mapping out and documenting the process to best reflect the various concurrent undertakings, feedback loops, refinements and revalidation of past steps.

The background is presented in the first chapter. The second chapter develops guiding principles for implementing cumulative effects assessment by reviewing the debates over the concept. Chapter 3 examines the results of the major case study as well as key issues and features from the literature, and uses these building blocks to develop a conceptual framework for CEA. An approach for implementing the conceptual framework, aimed at practitioners and outlining the major steps to be undertaken in the most logical order possible, is outlined in Chapter 4. The fifth chapter provides an overview of three cases that were used to evaluate the effectiveness of the approach. Conclusions are presented in the last chapter.

CHAPTER TWO

THE DEBATES OVER CEA: TOWARDS A WORKING UNDERSTANDING OF CUMULATIVE EFFECTS

2.1 WHAT IS MEANT BY CUMULATIVE EFFECTS?

2.1.1 Definitions

The concept of cumulative effects assessment is easiest to grasp on an intuitive basis. The “*cumulative effects of everything*” (Ross, 1994) are what we observe in real life: this is much more tangible than abstracting effects of a single project from its surroundings and context. However, intuitive concepts may be difficult to define: this is certainly the case for cumulative effects assessment, which has been debated since the first definition was proposed through the United States National Environmental Policy Act in 1969 (NEPA, 1969).

The *Canadian Environmental Assessment Act* provides a definition of cumulative effects only indirectly through its accompanying *Reference Guide on Addressing Cumulative Environmental Effects* (FEARO, 1993a). Since the *Act* applies to projects only, the reference guide focuses on project-level assessment, defining cumulative impacts as the effects of a project combined with those of past, existing or imminent projects or activities, which may occur over a certain time or distance. The *Reference Guide* also states that combinations and

interactions of individual human activities may lead to aggregate effects that differ in nature and extent from the effects of the individual activities, thus resulting in functional or structural changes to the ecosystem, and that these must be addressed through the adoption of a broader perspective, that of “thinking cumulatively”, which requires a focus on broad temporal and geographic boundaries and interactions among effects.

For the purposes of this thesis, two minor modifications are proposed to the above definition. First, the word “project” is replaced by “proposal” to more fully reflect the range of human activities that can contribute to cumulative effects. Second, the word “future” has been substituted for “imminent” to broaden the range of activities that may be considered in the analysis. As a result of these changes, the following definition is proposed: *“The effect on the environment which results from effects of a proposal when combined with those of other past, existing and future projects and activities. These may occur over a certain period of time and distance.”* (modified from FEARO, 1993a).

This definition provides a starting point for considering the elements and characteristics that merit further investigation to implement a working understanding of the concept.

2.1.2 Attributes of cumulative effects

There is emerging accord over the attributes of cumulative effects. Perhaps the most

important characteristic is the expansion of perspective which results from the recognition that impacts accumulate at scales that are broader than those from which they initially originated. Effects may be felt at locations far from their source of origin, or after significant lapses of time. Impacts may occur so closely together that the affected system fails to recover: this may happen either gradually or suddenly if critical thresholds are exceeded. System behavior may be complex and non-linear, making predictions very difficult.

Frequency of effects, also referred to as *crowding*, has also been cited as a fundamental component of CEA. According to Orians (1986):

"...cumulative effects are important when the frequency of occurrences of individual perturbations is high enough that the system has not recovered from the previous ones at the time the next ones arrive. Similarly, cumulative impacts occur when the distance between perturbations is such that individual effects have not declined to zero at the point where the effects of neighboring perturbations are no longer felt. Finally, cumulative impacts may arise when different types of perturbations cause similar environmental effects, provided that they fulfill the time and space criteria mentioned above."

Cocklin et al. (1992a) pointed out that *"it is difficult to envisage a situation in which time crowding would be significant in the absence of space crowding and vice versa."*

In general, characteristics of cumulative effects include: accumulation over time and space; time lags; space lags; compounding effects; synergy; indirect effects; triggers and thresholds; cross-boundary movements; fragmentation; complex system behavior including fundamental changes in structure or function. Several systems have been proposed to classify the

attributes of cumulative effects. One of the first of such typologies, based on issue type, was put forth by Sonntag et al. (1987), as presented in Table 3.

Table 3: Attributes of cumulative effects by issue type
(adapted from Sonntag et al., 1987)

ISSUE TYPES	CHARACTERISTICS
time-crowding	frequent and repetitive impacts - impacts which occur so closely over time that the recovery rate of the environment is exceeded
space-crowding	high density of impacts on a single medium - impacts which occur so closely together that their effects overlap
compounding effects	effects from multiple sources which interact so that the overall significance is greater than the sum of individual effects; synergism
time lags	delays in experiencing impacts
space lags	impacts occurring at a point distant from their source of origin
triggers and thresholds	levels of impacts that fundamentally change system behavior
indirect effect	secondary effect resulting from a primary effect
nibbling	impacts which accumulate through insignificant increments

Classification of cumulative effects has also focused on the agents of change, including both single and multiple sources. A single cause may lead to cumulative effects when it is persistent and repeated. Most frequently, cumulative effects will be caused by several different agents of change acting upon a system through a combination of their individual effects. (Sadler, 1986; O'Riordan, 1986).

The *assessment* of cumulative effects has been characterized as the provision of a holistic *context* (Duinker, 1994), a *perspective* (Roots, 1986) and a *way of thinking* (Bronson et al., 1991; FEARO, 1993a), usually involving a comprehensive, interdisciplinary and interorganizational approach (Sonntag et al., 1987). In a report of the U.S. Council on Environmental Quality (CEQ, 1996) cumulative effects are viewed as the total effects acting upon a given resource or ecosystem, caused by the aggregate of past, present and reasonably foreseeable future actions; because of the vastness of this concept, the assessment of such effects must necessarily focus on the truly meaningful impacts, in terms of their capacity to accommodate additional effects.

2.1.3 Challenges in assessing cumulative effects

Conventional EA has generally failed to adequately consider cumulative effects. Initially, a reactive project-specific approach to EA was adopted that focused on short-term local issues, failing to promote the assessment of multiple activities, the use of common goals or ecosystem objectives, or even the analysis of an adequate range of alternatives. Interactions and accumulation of impacts were not generally recognized: future growth potential of projects being assessed was often ignored.

Perhaps the single greatest challenge to assessing cumulative effects stems from its cross-jurisdictional/cross-institutional nature. Traditionally, it has been the responsibility of

individual agencies to direct the assessments of their own proposals, focusing on their particular sector of interest, regardless of jurisdictional fragmentation. This created a serious problem: for example, one study showed that up to 400 agencies make decisions which can affect a single mile of the San Francisco Bay Delta (CEQ, 1996). It is easy to appreciate the reluctance of an individual proponent to assess all the activities and proposals put forth by other stakeholders in the area, or to attribute responsibility for past impacts and mitigation. The task of identifying future projects would be even more daunting, particularly when proponents are private individuals. In the absence of a single co-ordinating agency responsible for a spatial area defined by natural boundaries, it can hardly be surprising that cumulative effects were not factored into the picture.

The various technical, scientific and institutional barriers to assessing cumulative effects are not insurmountable, however; recognizing the difficulties is the first step in finding solutions.

2.2. POSITIONING CEA IN THE DECISION-MAKING HIERARCHY

2.2.1 The “project-versus-planning” debate

Debate has emerged over whether CEA should be viewed primarily as a scientific or planning-oriented exercise (Cocklin and Parker, 1991; Spaling, 1993; Spaling and Smit 1993). In the first approach, CEA is viewed as *an extension of environmental assessment*,

an analytical, information-gathering exercise where results are communicated to decision makers to promote rational, informed choices. This approach is viewed as reactive, in that the process is triggered once a development project is already in the works, and hence fails to consider alternatives to the project.

The second approach views EA as generally unable to adjust to the broader scales and scope required for assessing cumulative effects. As a result, CEA is seen primarily as a *regional planning exercise*, consisting of a process of goal setting, issues definition, development and evaluation of alternatives, and selection of a preferred solution. The assessment is generally focused on a region rather than on an individual project or activity.

Essentially, the above debate focuses on positioning CEA in the decision-making hierarchy. Simply put, should cumulative effects be assessed at the project level, to understand the potential consequences in terms of other existing proposals and the surrounding environment? Would it be more effective to direct the assessment of cumulative effects at strategic decision-making levels, such as the regional planning level where critical decisions are being made? Are these positions necessarily exclusive?

Spaling and Smit (1993) reviewed both approaches, and concluded that the analytical approach is the most common simply because it is promoted by the existing legislative and administrative context. However, advances in both approaches are occurring, often

simultaneously and in a complementary manner. For example, the assessment of cumulative effects under NEPA is considered an extension of EA yet, application of CEA at the planning level is also encouraged (CEQ, 1996). The two approaches, then, are not mutually exclusive; both are essential for effective management of cumulative effects (Stakhiv, 1988; Spaling and Smit, 1993). An appropriate balance may be achieved by undertaking assessments throughout the decision-making hierarchy in a process called “tiering”.

2.2.2 Applying CEA at strategic levels

The environmental assessment of strategic-level proposals such as policies, programmes or plans has been termed “strategic environmental assessment” (SEA). Definitions of strategic environmental assessment usually involve reference to tiering. Gilpin (1995) states that *“There is a growing conviction that matters cannot be completely resolved at project level when many matters have been decided already at a higher level.”*

A study by the *Federal Environmental Assessment Review Office* (FEARO, 1992) identified six compelling reasons why application of EA to policy is vital to good public decision making:

1. to determine the fundamental feasibility of public initiatives and the soundness of underlying principles;
2. to anticipate problems early enough to consider a wide range of alternative solutions in a proactive manner;

3. to assess broad directions and orientations which do not lead to specific programmes or projects, and for which there may be no further opportunity of review;
4. to assess cumulative and socio-economic consequences;
5. to help define key issues to be assessed at a more specific level; and
6. to bring environmental considerations into the mainstream of planning and decision making.

Strategic environmental assessment provides an opportunity to incorporate long-term environmental goals at higher levels of decision making, anticipating and preventing effects before they occur at the project level (Sadler and Jacobs, 1990b). The assessment of conceptual proposals is necessarily different from project assessments, since the analysis focuses on broad conceptual issues rather than specific details relevant to a given project. Most challenging is the assessment of conceptual proposals which do not relate directly to a geographical area. Many policies, and programmes, and some types of plans fall within this category. Methods and procedures are currently being developed for such assessments; several key considerations have been proposed, including ensuring consistency between related policy objectives (Leung, 1985), focusing on anticipated outcomes (Shillington and Burns et al., 1996), and integrating environmental and other implications into the policy development process (Bregha et al., 1990).

An “integrated approach” to policy assessment may be reinforced by complementary initiatives such as audits, sustainable development strategies, and the development of indicators to gauge success (Bregha et al., 1990). Recently, changes to the *Auditor-General Act* direct all federal departments to prepare sustainable development strategies, which set

out the various departmental goals, action plans and initiatives to implement sustainable development. Such strategies generally recognize the role of environmental assessment and support best professional practice within the EA process. Strategic environmental assessment is recognized as the principal tool to ensure the integration of environmental considerations into broad departmental policies and programmes.

The environmental assessment of plans occurs more commonly than conceptual policy assessments: the integration of EA into planning is facilitated by their inherent similarity (Klein, 1993; CEQ, 1996) and is seen as an improvement to both processes (Peterson et al., 1987). Both involve steps such as the identification and validation of broad goals and objectives, the exploration of long-term consequences of alternative strategies, and monitoring system response (Sonntag et al., 1987; Munn, 1994). Their co-evolution towards a more comprehensive approach can provide an effective context for the assessment and management of cumulative effect (Sonntag et al., 1987). In some cases this may occur by tightly linking both processes or by combining them to produce a new form of planning in which environmental considerations are integrated from start to finish (Lane et al., 1988; Armour, 1990).

An example of co-evolution is provided by the assessment of the Fraser River Estuary Management Plan. Dorsey (1987) points out that project-level assessment was broadened to cover a wider region and multiple issues, while the management planning process evolved

to provide more specific direction and context to projects. In preparing a guidebook for “areawide assessments” (Skidmore, Owings and Merrill et al., 1981), the authors noted that the process that emerged was “more than EA” as it becomes integrated into the comprehensive planning process.

In many cases, however, CEA may occur separately from the planning process, with imperfect feedback, or none at all. For example, Hubbard (1988) concluded that barriers such as lack of political commitment, jurisdictional fragmentation and technical difficulties prevented the use of CEA in regional planning in southern Ontario. Similar constraints were identified in a study focusing on the Greater Vancouver Region (Colnett, 1991). Beanlands (1992) cautions that the “longer-term, strategic, inter-generational aspects of sustainable development and cumulative effects management” are lacking in most broader scale planning exercises.

Despite the challenges, there are many examples of successful incorporation of cumulative effects assessment into the planning levels (Johnson, 1982; Burdick et al., 1989; Gosselink and Lee, 1989; Gibson, 1990; Glaholt, 1994; and others). There are five main benefits to integrating CEA into planning levels:

1. Many impacts accumulate at the regional or landscape level, which then provides an excellent perspective for their analysis (Skidmore, Owings and Merrill et al., 1981; Burdick

et al., 1989; Gosselink and Lee, 1989; Cocklin, 1993). In fact, some long-term effects, such as global change, can *only* be investigated from a regional perspective through policies and plans (Munn, 1994).

2. A regional perspective allows the identification of baselines, trends and thresholds, which can then provide the context required for project-level assessments (Rees, 1988; Dias and Chinery, 1994).

3. Regional analysis can focus on the full scale of impacts, including multiple initiatives, and past, present and future proposals, as well as the linkages and interactions between those effects (Cocklin and Parker, 1991; Contant and Wiggins, 1991).

4. A regional perspective provides a forum for assessing issues that would not trigger an assessment at any other level (Irwin and Rodes, 1992). This is true both for broad regional policy issues such as zoning proposals, as well as for multiple small projects that are insignificant when taken individually (Odum, 1982; Bregba et al., 1990; Cocklin, 1993). Effective CEA can help a plan avoid contradictions by considering the full implications of guidelines (Sebastiani et al., 1989).

5. Assessments at the planning level can be more proactive, and give greater substance to sustainability by considering a greater range of alternatives (Rees, 1988; Cocklin and Parker,

1991). The planning exercise also provides a forum for consultation, for developing common goals and objectives, and for negotiating co-operative multi-jurisdictional agreements. Such efforts increase the chances of successfully managing cumulative effects (Peterson et al., 1987).

2.2.3 Applying CEA at project levels

Does the assessment of cumulative effects at the policy and land use planning levels obviate the requirements for their consideration at the project level? Cumulative effects originate at the level of individual projects and most EA processes are applied at this level; it therefore makes good sense to assess cumulative effects at the project level (Cocklin and Parker 1991; FEARO, 1993a; Doyle, 1994; Drouin and LeBlanc, 1994; Lawrence, 1994). Effective feedback to the planning level, however, can provide the context required for the assessment of cumulative effects. Roots (1986) described this as follows: *“Cumulative effects assessment is not a methodology for adding together assessments of separate projects, but rather a means for putting the effects of any project into the perspective of larger dynamics of human activities and environmental change.”*

Site-specific issues usually cannot be addressed adequately at higher levels and can be very relevant to cumulative effects, especially in terms of verifying consistency with thresholds or carrying capacity. Relevant biophysical information may not be available at all scales.

For example, Beanlands and Duinker (1983) showed that biological information is more readily available at individual levels rather than population levels.

Project-level assessments may also uncover deficiencies in the tiering system. Policies or plans may be missing, or may not have been assessed. Small incremental effects that have escaped notice so far may be identified as issues at the project level; for example, an assessment triggered by the construction of a stormwater outlet may focus attention on the effects of stormwater and the absence of a watershed plan.

In a sense, plans are validated by project-level assessment. Unanticipated effects observed at the site level may identify trends which were not addressed in the plans, leading to the development of new thresholds. Plans may often be too vague to provide adequate guidance at the project level, especially where difficult issues such as carrying capacity must be resolved. Site assessments provide an opportunity to “ground-truth” the success of broader environmental policies.

2.2.4 The concept of tiering

The decision-making hierarchy (Figure 1) translates societal values into broad policy orientations that lead to more specific programs and plans which themselves eventually result in projects (Bregha et al., 1990). The environmental assessment of a project cannot

include the assessment of all the first principles which led to the development of the proposal without an unmanageable broadening of the scope of the assessment. More effective scoping can be achieved by tiering environmental assessments so that concepts are assessed as they evolve through the hierarchy as nested choices.

Figure 1
The decision-making hierarchy

Tiering has been defined as *“the process of addressing a broad, general program, policy or proposal in an initial Environmental Impact Statement (EIS), and analyzing a narrower site-specific proposal, related to the initial program, plan or policy in a subsequent EIS”* (CEQ, 1983, quoted by Bregha et al., 1990). In this way every assessment may be scoped to address more effectively the issues appropriate to the level of decision making, with different scales of issues examined at each level. Environmentally sound first principles will lead to better alternatives at the next level of decision making, in a domino effect. Each level of assessment makes an important contribution without duplicating previous levels. Information needs can be addressed at overall and site-specific levels (Hirsch, 1988).

Most EA regimes incorporate some aspects of tiering. Spaling (1993) argues that the original mandate of NEPA called for comprehensive regional planning rather than a focus only on the project level. The “early-application” principle of the 1984 federal Environmental Assessment Review Process Guidelines Order (EARPGO) in Canada has been interpreted as a requirement for policy-level assessments.

If all decision making occurred in neat hierarchies, tiering would solve many of the problems associated with cumulative effects assessment. In real life, however, many small decisions are made without being addressed from an overall policy perspective, in what has been labeled the “tyranny of small decisions” (Odum, 1982). The consequences of these small decisions may gradually add up to “destruction by insignificant increments” (Gamble, 1979). Odum (1982) illustrated this through the example of coastal wetlands: *“No one purposely planned to destroy almost 50% of the existing marshlands along the coast of Connecticut and Massachusetts. In fact, if the public had been asked ... preservation would probably have been supported.”*

Dealing with such unanticipated impacts requires a concerted effort at all levels of decision making, with effective feedback between tiers. For example, regional impacts such as reduced flood moderation and loss of water quality were associated with cumulative loss of wetlands. Solutions involved all levels of decision making, ranging from no-net-loss policies at the national level to regional watershed plans and development of local standards (Irwin

and Rodes, 1992). The development of site-specific or regulatory solutions requires information on the broader perspective, all of which can be addressed by cumulative effects assessment when feedback mechanisms are in place.

The promotion of effective linkages between the decision-making levels has been identified as a key strategic issue for analysis and research (CEARC, 1988). Irwin and Rodes (1992) suggest that this should occur through comprehensive state strategies such as co-ordination of wetland policies. Doyle (1994) recommends the use of indicators and state of the environment reporting. Regularly-scheduled plan updates, integrated monitoring programs or resource management processes can also provide feedback opportunities.

The above considerations suggest that tiering is *essential* for effective assessment of cumulative effects, and that proposals must be assessed at *every level* of decision making. Each level has its own unique role to play, and since effective feedback eliminates duplication, each level can focus on issues most relevant to the decision at hand. The land use plan level provides the optimum scale for assessing cumulative effects, and feedback linkages from this level will be especially important. Such linkages occur upwards since regional land use plans provide critical feedback to policy; for example, thresholds determined at the regional level may lead to national no-net-loss policies. Key feedback also occurs from plans to projects, as land use plans provide the context for site-specific assessments. Feedback at other levels is also important. The state of the environment at

specific sites may indicate the need for changes at the planning level; new issues may be raised requiring new plans or policies. Figure 2 illustrates the tiering/feedback concept for CEA.

Figure 2
Hierarchy of triggers for cumulative effects assessment

2.3 ADOPTING A BROADER PERSPECTIVE

2.3.1 The importance of scales

Inadequate perspective has led to a mismatch between the scales at which problems accumulate and the scales at which decisions are made (CEARC and U.S. NRC, 1986; CEQ, 1996). Mismatches may involve the failure to consider broader level consequences (Irwin and Rodes, 1992), the failure to account for the full costs of eventual ecological

consequences (Stigliani, 1988), spatial discrepancies such as a difference between human and ecosystem time frames (Gosselink and Lee, 1989), or institutional discrepancies when impacts cross jurisdictional boundaries (Irwin and Rodes, 1992). Mismatches result in decisions that are based on partial information only, with little understanding of the ultimate consequences.

The avoidance of mismatches rests on effective scoping of issues identified at adequate spatial and temporal scales. Debates over the selection of appropriate scales are all the more difficult to resolve given the paucity of assessments covering very large temporal and spatial boundaries (Sonntag et al., 1987; Peterson et al., 1987). Despite the challenges, it is useful to explicitly identify the boundaries for an assessment (Preston and Besford, 1988). However, they must be flexible: *“Boundaries help to rationalize the assessment task, but should not constrain the analysis unrealistically. Boundaries help to establish the extent of the analysis, but should always be treated flexibly - environmental change pays no heed to the artificial spatial and temporal constructs imposed by humans”* (Cocklin et al., 1992a).

2.3.2 Scale-dependent variables

Many of the variables in an EA are scale-sensitive and it is important to understand how they are affected when perspectives change. Issues and concerns will vary according to scale, affecting the VECs and indicators selected, as well as the methods and techniques used in

the assessment and even the evaluation of significance.

When scales are broadened, a corresponding shift must occur in the level of issues examined. For example, worldwide indicators of sustainability, such as genetic diversity or water regime integrity, may be used in assessments when very large scales are involved (Spaling and Smit, 1993). Effective scoping of issues can prevent the assessment from becoming unmanageable (Gosselink and Lee, 1989).

In terms of VEC selection, the scale of the analysis will determine whether individuals, populations, communities or ecosystems should be considered (Beanlands and Duinker, 1983; Roots, 1986). Focusing on relevant levels of organization is an effective means of managing complexity without resulting in more cumbersome assessments, since a shift in scale will result in a new level of understanding and generalization (Roots, 1986). By changing the type of data collected, the overall amount of information required remains manageable. In their work on cumulative effects of wetland loss on landscape function, Bedford and Preston (1988) demonstrated that *“improving the scientific basis for regulation will not come merely from acquiring more information or more variables. It will come from recognizing that a perceptual shift in temporal, spatial and organizational scale is overdue. The shift in scale will dictate different - not necessarily more - variables to be measured in future wetland research and considered in wetland regulation.”*

Shifts in scale will also entail modification of approaches and techniques (Spaling and Smit, 1993) although the same techniques may be applied directly for smaller scale CEAs . For example, Walker and Walker (1991) adjusted data sources and techniques such as GIS, photo interpretation, digital terrain models and point sampling according to the scale assessed.

Significance is also scale-dependent (Norton, 1992) and assessments of significance must show which baselines and thresholds were used.

2.3.3 Matching the level of decision to the scale of the problem

It is critical in cumulative effects assessment to avoid a mismatch between the scales at which problems accumulate and the levels at which decisions are made. In summarizing the conclusions of a 1986 workshop on cumulative effects, Roots (1986) noted: “*The most pervasive management issue seemed to be the proper matching of the scale of management to the scale of the cumulative effect.*” Two techniques can help avoid mismatches should they be detected: effective tiering and effective scoping.

Scoping identifies the key issues that the assessment should address, based on a comprehensive perspective of the existing environment, and the various stressors affecting it. The extent and magnitude of the potential effects guide the scale of the assessment, as will values and ecological considerations. These factors are interdependent and the process

of scoping boundaries is iterative. The selection of boundaries provides an opportunity to compare the scales of the cumulative issues resulting from a proposal with the scales of the decisions being made (Irwin and Rodes, 1992). Boundaries selected should be viewed as flexible guidelines rather than rigid constraints.

In some cases, avoiding mismatches may mean that the scope of the assessment must extend beyond the scope of the project. For example, a permit for wetland drainage may raise issues relating to cumulative loss of wetlands on a regional scale and resulting loss of habitat and flood control function. This is obviously beyond the scope of a single permit, yet clearly involves an impact which must not be neglected. Effective tiering alleviates this problem and helps avoid such mismatches. Broad standards and thresholds established at the regional or watershed level provide the perspective to guide project-level assessments (Irwin and Rodes, 1992).

As shown in Figure 3, the level of decision and the scales of issues to consider are usually linked within a nested decision-making framework. At one end of the scale, broad policy issues involve long-term considerations at national or global levels, sometimes unrelated to specific spatial areas. At the other end of the scale, projects are concrete, specific developments that are clearly anchored to a specific location. Plans are intermediate between

projects and policies in that they may deal with broader policy issues as well as site-specific proposals. The assessment of projects should tend towards ecosystem boundaries and medium-term time frames. Assessing plans often means considering the broader ecosystem and longer time frames, while policies may encompass very broad issues over the long term. Thus, successive levels of decision-making generally correspond to broader spatial and

Figure 3
Links between conceptual level of decision making and geographical scale

temporal boundaries. As issues become broader and more conceptual, a greater integration of the EA into the decision making process is required. However, within a given region, all levels are ultimately interlinked both conceptually and spatially.

2.4 DEFINING THRESHOLDS AND LIMITS

2.4.1 The notion of thresholds and carrying capacity

For impacts to accumulate, the rate of change must be such that a system cannot recover from an effect before the next ones occur. However difficult it is to measure or define the specific point (or range of points) at which interactions over time or space become a concern, recognizing the very existence of thresholds distinguishes cumulative from single-shot impacts. This is true regardless of whether the changes are initially masked or immediately apparent, and whether the rates of change are additive or non-linear. Thus, the concept of thresholds is inherent to the very nature of cumulative effect.

However, the terminology is somewhat confusing. The term “threshold” has been used in a generic sense to denote a limit beyond which a change is perceived as unacceptable. The CEQ (1996) defines thresholds as “*levels of stress beyond which the desired conditions degrade.*” Ziemer (1994) suggests that thresholds represent the “*point at which the public becomes adequately alarmed and demands action.*” Thresholds have also been used in a thermodynamic sense to denote a limit beyond which system characteristics change in rapid and often catastrophic ways. Cocklin et al. (1992a) refer to thresholds to denote the point at which a linear process of change suddenly becomes non-linear, as exemplified by incremental forest loss which suddenly reaches a critical point for habitat preservation.

To avoid confusion, the term threshold will be used in this thesis in its generic sense to refer to the point at which cumulative effects become a concern, either for perceptual or scientific reasons. The term “critical threshold” will be used to denote sudden or catastrophic changes, or changes from a linear to non-linear process.

2.4.2 Types of thresholds for CEA

All thresholds reflect varying combinations of scientific data and values. In this sense, system targets or objectives, standards and guidelines, carrying capacity, and limits of acceptable change are all expressions of system thresholds. Targets primarily reflect societal values and goals determined through a consultative process; they usually have a positive connotation (a desired state to aim for) rather than a negative connotation (unacceptable levels of degradation). Targets may be linked to rehabilitation initiatives, such as efforts to bring populations of rare species up to a specific level.

Standards and guidelines generally reflect tolerable levels of change rather than desirable conditions (Sallenave, 1994). For example, degradation of water quality may be seen as acceptable up to the specified quality guideline. Standards may vary depending on established goals: for example, standards for drinking water will differ from recreational water quality norms.

Assimilative capacity generally refers to the physical capacity of natural processes to absorb change (Spaling, 1993). Carrying capacity is a term that evolved from wildlife management, referring to the maximum population size an area could sustain. In relation to cumulative effects, the term denotes a maximum level of use or development beyond which unacceptable damage will occur to the system, as determined both by goals and assimilative capacity (Spaling, 1993). Carrying capacity is dependent upon values and contexts (Godschalk and Parker, 1995; Bradley, 1996). This suggests that it is prudent, when using the term carrying capacity, to specify a reference point such as biophysical or social capacity.

It is because carrying capacity is not strictly a scientific concept, relating as it does to both science and values, that its application has been difficult: it involves developing a level of consensus over goals and appropriate use. Without such a consensus or clear statement of values, maximum levels of use may be interpreted as targets that then can be shifted upwards by lowering standards or increasing site hardening. Wight (1994) cites the example of the Galapagos Park Master Plan which increased the cap on visitor use levels by increments from 12,000 visitors in 1973 up to 42,000 in 1989. For these reasons, recently developed approaches for sustainable tourism have avoided the use of carrying capacity in favor of monitoring environmental indicators of desired conditions (Consulting and Audit Canada, 1995; Manning and Dougherty, 1995).

Despite the difficulties, the concept of carrying capacity can be very useful. It illustrates,

however subjectively, that biophysical, social or recreational limits are real. It can provide a direction for professional judgement and research. In the words of Godschalk and Parker (1995): *“Carrying capacity does not replace judgement but it can help to inform it, just as it does not replace scientific research on environmental cause and effect relationships, but it can help to focus that research on concrete policy issues.”*

The concept of “limits of acceptable change” evolved from a shift in focus from appropriate levels of use to descriptions of acceptable conditions, which are independent of maintenance factors. (Stankey et al., 1984; Wight, 1994). Setting broad ecological objectives to define limits of ecosystem tolerance can serve as a surrogate for carrying capacity (Sallenave, 1994). Once managers have determined which conditions are deemed “acceptable”, they can identify the appropriate combination of use and development required to sustain those conditions. Thus, determining the “limits of acceptable change” can help achieve a balance between conflicting goals of conservation and use. Wight (1994) notes that this technique should only be used when such conflicts exist; in all other cases management should aim for optimal conditions (as determined by public interest) rather than acceptable (or sub-optimal) conditions.

Despite the debates over how they should be expressed, it is generally agreed that recognizing thresholds is beneficial. Often it is the very process of identifying which thresholds are acceptable that provides the forum for defining and interpreting limits, which

is a necessary step for achieving sustainability (Sadler and Jacobs, 1990b).

2.5 SCIENCE, VALUES AND UNCERTAINTY

2.5.1 The role of science in CEA

There have been numerous calls for increasing scientific rigour in environmental impact assessments, including the assessment of cumulative effects (Sprague and Sprague, 1976; Beanlands and Duinker, 1983; Baskerville, 1986; Preston and Besford, 1988; NEB and CEAA, 1996). The increased level of uncertainty brought about by the need to consider a greater number of variables over broader spatial scales and longer periods of time makes the use of science more challenging. It is critical not to lose sight of the primary purpose of environmental assessment, which is to support good decision making, rather than promote scientific understanding (Cartwright, 1991; Morrison, 1994). Emphasis must be placed on practicality, manageability, usability, cost-effectiveness and professional judgement. Experimentation and hypothesis generation may not always be appropriate to the issues at hand: *“It is of vital importance to the EA process in Canada to ensure not only that rigorous statistical methods are used where appropriate, but that other criteria may be developed to consider those instances in which traditional statistical methods are not appropriate”* (Lane et al., 1988).

In some cases, the need for scientific rigor is driven not by the need to develop more meaningful CEAs but by legislative requirements: *“The basic problem faced by ecologists is that we cannot predict impacts at the ecosystem level with the degree of precision that is demanded by the regulatory models developed by our lawyer and engineer friends. Furthermore, let us not delude ourselves, we will never be able to develop the kind of precision that current approaches imply and demand.”* (Hamilton, 1986). This is especially relevant to CEA, where larger scale problems usually mean lower levels of resolution (Bedford and Preston, 1988). The quest for levels of precision that are higher than necessary can thus compromise the primary purpose of EA (Regier, 1986).

2.5.2 Uncertainties in predicting and modeling cumulative effects

Predictions and models are more difficult to generate in CEA because of the broader scales and increased number of variables and interactions in the analysis. When the number of variables increases to more than three, it can be nearly impossible to determine the relative importance of each factor (Harris, 1988). Difficulties and uncertainty can arise in establishing cause-effect linkages, identifying dynamic interactions, and developing thresholds (Davies, 1992). In the words of Milne-Ives (1991): *“What biologist, when confronted with the apparently impenetrable morass of factors involved in the interactions of even the simplest biological system, hasn’t suffered a pang of ‘physics envy’ - the desire to investigate a system that obeys well-defined laws of interaction that can be expressed with*

solvable, linear equations?”

The development of predictive models in any discipline involves generalizations and simplifications of reality. When knowledge is built upon such generalizations, practitioners may apply them to the real world without recognizing the level of abstraction involved (Daly and Cobb, 1989). Such misleading levels of generalization occur when abstract research is undertaken on highly generalized problems (Baskerville, 1986). In reality, most research occurs under laboratory conditions, or on small study plots over short time scales; for example, studies have shown that the majority of ecological investigations have occurred on spatial scales of less than one meter and time scales of less than one year (Woodley, 1993a).

One of the main contentions in the literature is that limits stem from ecosystem science itself. Baskerville (1986) noted that only the most “trivial predictions” could be made concerning long-term cumulative effects and that “*major advances in basic ecological research are required to provide a sound basis for a technology of impact assessment and prediction.*”

Questions may arise not only concerning the accuracy of predictive models, but also about the predictability of systems themselves. Recent developments in chaos theory suggest that many systems are more complex than originally thought. In fact, chaos, which has been defined as “order without predictability” (Cartwright, 1991), is perhaps much more the rule than the exception (May, 1976). Chaos theory suggests that within most systems, there is a

critical point which triggers the onset of complex behaviour (May, 1976; Gleick, 1987). Complex regimes such as weather systems may completely defy predictions, even with a simple model in which all parameters are determined exactly, because their sensitivity to a large number of initial conditions can lead to widely divergent trajectories (May, 1976; Gleick, 1987). The uncertainty arises, not only from our models, but from how the world actually works.

What does this mean for cumulative effects assessment? Paradoxically, the inherent non-predictability of complex systems can simplify the process by shifting the focus to a different scale of science, looking for broad patterns rather than details. In investigating the implications of chaos theory to planning, Cartwright (1991) concluded that the high levels of uncertainty associated with long-term predictions are here to stay, but that the rules associated with complex behaviour may not be impossible to predict. He promotes the use of “intelligent scanning”:

“Rather than looking for more detailed information and ever more accurate models of their systems, planners should look instead for patterns of system behaviour, or points to which systems seem to return, ...even if not predictable in any way.”

Strategies developed to accommodate high level of uncertainty include multiple-scenario building, increased monitoring, and feedback. Most of these solutions are now being applied in cumulative effects assessment.

2.5.3 Uncertainties in determining values and responsibilities

Most decisions and choices stem from values, which cannot be provided through science. Sonntag et al. (1987) concluded that ecological predictions are difficult to make, not only because of uncertainty in ecosystem science, but also because of uncertainties about societal values. In many cases impacts may not be predicted by unbiased scientific means because changes that are relevant to stakeholders may not be measurable (Ministerie von Volksgezondheid, 1981). The involvement of multiple agencies and jurisdictions in cumulative effects assessment heightens the need for a framework in which concepts and concerns of both science and society can be accommodated.

Multiple contributors to overall effects complicate the determination of significance and the division of responsibility for mitigation and monitoring. Ambiguities also arise when individual contributions to an overall problem are each insignificant. Increasingly, however, legal precedent suggests that responsibilities can nonetheless be established (Locke, 1994). In some cases the creation of multi-jurisdictional planning boards may be required to resolve such issues (Bennett, 1994).

It is difficult to avoid controversies surrounding the issue of “burden of proof” when levels of uncertainty are high. This is a fundamental question for cumulative effects assessment: is it up to the proponent to prove that a proposal will not lead to unacceptable cumulative

consequences or is it up to the assessment to prove that a proposal is unacceptable? Glantz and McKay (1986) link these questions to the “bottom line” issues of “who pays”: *“Should the dictum that the polluting factory be considered innocent until being proven guilty apply? Can it be proven beyond a reasonable doubt? How can the ‘polluter pays’ principle be reconciled to the ‘innocent until proven guilty’ principle before it’s too late and society at large has paid an unacceptable price? Is the ‘polluter must pay’ principle applicable to regional and global issues?”* They conclude that lack of action to remedy cumulative effects stems, not from a lack of meaningful CEAs, but from political/economic reasons and scientific uncertainties.

2.6 GENERATING PRINCIPLES OF CEA

2.6.1 Principle 1: Environmental assessments should be tiered

One way of dealing with the mismatch between the scales at which impacts accumulate and the scales at which decisions are made is by tiering environmental assessments, that is, undertaking EAs at all levels of decision making. At strategic levels, environmental assessments should be tightly integrated into the proposal development process. Strategic environmental assessments will greatly simplify the scoping process for subsequent project assessments. Feedback and linkages are essential throughout the assessment hierarchy.

To effectively assess cumulative impacts, strategic environmental assessments must be timely and results must be incorporated into ongoing policy decisions. Strategic environmental assessments must also be proactive in highlighting to what extent key decisions are addressing the cumulative consequences of past, present and known future projects and activities.

Effective strategic-level assessments simplify but do not eliminate the need for assessing potential cumulative effects through project EAs. Site-specific issues will need to be resolved within the context provided by the policy assessments. Since project assessments are less conceptual in nature and are linked to a specific geographical area, they can present an opportunity to “ground truth” previous work. In some cases project assessments may highlight new issues or concerns that must be dealt with at the policy level.

2.6.2 Principle 2: The critical focus for CEA is the ecosystem management level

While cumulative effects must be assessed at all levels of decision making, the ecosystem management planning level provides the most opportune perspective for CEA. The ecosystem scale is critical since effects which originate locally tend to accumulate at higher scales such as the regional ecosystem or landscape, and are therefore most visible from these perspectives. The management planning level is also critical since it develops strategic directions for heritage areas, establishes strategies for conservation and use, and provides

direction for multiple proposals. Planning thus presents a context for assessing the overall consequences of human-induced changes upon the greater ecosystem in light of existing goals and objectives. It is most effective to assess cumulative effects at the level where such strategic decisions are made since many of the impacts occurring within heritage areas stem from levels or patterns of use. It is also critical to proactively integrate environmental considerations relating to cumulative effects within overall tools such as zoning.

Current National Parks policy directs management plans to “*contain statements of management objectives in sufficient detail to indicate how a park will protect and represent the natural and cultural aspects of its region*” (Department of Canadian Heritage, 1994a). An environmental assessment at this level will therefore provide insightful information on the cumulative consequences to ecological or commemorative integrity of the various management alternatives and choices.

To be successful, such assessments should be fully integrated into the management planning *process*. The scope of the assessment will require adjustments to reflect natural rather than jurisdictional boundaries. Since external stressors frequently affect heritage areas, collaborative management agreements and programs with external land holders, municipalities and other stakeholders will be required to assess and manage cumulative effects.

2.6.3 Principle 3: Analyze trends and thresholds through key components and indicators

Most cumulative effects are the result of impacts crowding in time or space, beyond the recovery rate of the affected system. EA practitioners must determine where this crowding occurs and how significant it is. This cannot be evaluated without *benchmarks* to help establish what the acceptable limits of change are and to what extent the accumulating effects are approaching those limits. The *recognition* and *identification* of the benchmarks are critical to CEA; the *nature* of the benchmarks is highly adaptable. Specific thresholds or carrying capacity may be available; limits may also be provided by legal or scientific standards. In other cases, trends may provide an indication of limits of change without the identification of quantitative thresholds.

Effective scoping can identify a set of key components of the environment that are diagnostic indicators of ecological or commemorative integrity. Key components may also be early warning indicators of system stress, or may be selected to provide information on heritage area goals or critical issues, known impacts of concern, or known sources of cumulative stress such as levels or patterns of use. Indicators may be used as surrogate measures to follow changes to key components over time. Thus, the trends exhibited by selected indicators and key components will provide valuable information on cumulative effects.

2.6.4 Principle 4: Minimize uncertainty through a cautious approach, integrated monitoring and feedback

Uncertainty is unavoidable when dealing with broad temporal and spatial scales and multiple variables. Cumulative effects are difficult to quantify, and limits and thresholds cannot be established with precision. As a result, environmental assessments should clearly identify assumptions and risks, including, in some cases, risks stemming from decisions where the ultimate consequences cannot be determined in advance.

There are two main tools for dealing with the high uncertainty involved in assessing cumulative effects in heritage areas. The first is the application of the precautionary principle, which has been defined as “*principles [that] emphasize the need for care and caution when changes to the natural environment are contemplated. This is particularly important when scientific understanding of a natural system is incomplete or when an area is unusually susceptible to damage*” (Page et al., 1996b). This means that decisions must always be made so as to minimize risks to long-term ecological or commemorative integrity of heritage areas. The implementation of preventative or remedial action must not depend on absolute scientific proof.

The second tool for dealing with uncertainty is the use of integrated monitoring. Monitoring programs constitute a legal obligation under the *Canadian Environmental Assessment Act*

when identified as a requirement in an environmental assessment. EA monitoring may be integrated with various other follow-up initiatives so that a single program provides mutually-supportive data for a given heritage area.

The results of monitoring must be fed back into the management and decision-making process, which must be flexible enough to adapt to new information or changes as required.

2.7 CHAPTER CONCLUSIONS AND NEXT STEPS

This chapter has provided a working definition of cumulative effects and has reviewed current debates over CEA, particularly its position in the decision-making hierarchy, the importance of scales, the roles of science and values, and the nature of uncertainty. Four guiding principles were developed based on the results of this review.

The next chapter examines organizing concepts and lessons learned from the major case study, from current practice and from the literature review in order to develop a conceptual framework for assessing cumulative effects within environmental assessment.

CHAPTER 3

TOWARDS A CONCEPTUAL FRAMEWORK FOR CEA

3.1 DIRECTIONS PROVIDED BY THE CASE STUDY

3.1.1 Selecting a major case study

The development of a conceptual framework for assessing cumulative effects should be based on a blend of practical and theoretical knowledge. For this reason, it was deemed important to undertake a case study early in the process in order to obtain overall direction which, in conjunction with information from the literature and input from actual cumulative effects assessments, would then provide the orientation for the CEA framework.

The Fortress of Louisbourg National Historic Site is located 35 kilometres southeast of Sydney, Nova Scotia. The site commemorates the 18th century Fortress of Louisbourg, and includes the reconstruction of the fortifications and one fifth of the original town, as well as numerous archaeological vestiges and a large natural area that constitutes the third largest protected area in Nova Scotia (Kalf, 1996). There were two main reasons for selecting the site for the case study. Firstly, the site includes an unusual combination of both natural and cultural heritage resources, and therefore provided an opportunity to ensure that the chosen approach is applicable to a broad range of issues relating to cumulative effects. Secondly, a project-level assessment was underway for a proposed highway that would bisect a portion

of the site. The case study could examine the linkages between a project-level assessment and the broader regional context of the heritage area.

3.1.2 General approach and results

An initial workshop was held with key stakeholders, including site wardens and archaeologists, staff from Parks Canada's Archaeological Research Branch, the Natural Resources Branch, and a consultant. The workshop identified past and existing projects and activities which lead to stress on resources, current issues of concern, key components and indicators, and some cause-effects linkages.

Further analysis was then undertaken; broad policy documents such as Parks Canada's *National Historic Sites Policy* (Department of Canadian Heritage, 1994a), the *Guidelines for Management of Archaeological Resources in the Canadian Parks Service* (Environment Canada, 1993) and the site Interim Management Plan, provided overall management goals and objectives. It was found that existing studies identified many of the stressors acting upon the site resources, often with associated cause-effect linkages. The analysis therefore focused on providing a systematic listing of stressors, estimating their importance in terms of frequency of occurrence and probable effects, and identifying major interactions. Difficulties were encountered, not with the identification of issues, but with *scoping* and eliminating of non-essential elements and issues. While existing trends were generally known, specific targets or objectives were usually unavailable, and evaluating the significance of actual and

potential changes was difficult.

One of the major issues raised in relation to cumulative effects concerned the future growth potential of the highway. Plans to upgrade an existing day-use area at Kennington Cove, and to enlarge the parking lot of the site visitor centre, were directly linked to the development of the Fleur de Lis Trail (Kalff, 1996). A highway is a classic example of a “driving variable” (CEQ, 1996), and associated developments such as gas stations and rest stops can lead to increasing pressure adjacent to the heritage area. The development of the highway can also create a precedent in terms of site boundary adjustments. In fact, the town of Louisbourg has already stated that present boundaries limit its future development potential and it has expressed a desire to expand into adjacent Parks Canada lands (Kalff, 1996).

A similar concern was related to the potential for future mineral exploration and extraction in the southwestern portion of the park where mineral rights have been retained by the province. Provision of access to this area, coupled with the economic difficulties faced by Cape Breton Island, could rekindle pressure for mining in the western portion of the site.

The case study demonstrated that the approach identified potential cumulative effects which could result from the proposed project, requiring more in-depth investigation and mitigation. Questions were raised concerning the assessment of cultural heritage resources (Kalff, 1996). These resources decay over time due to natural processes, and the identification of stressors and evaluation of significance requires expert opinion and professional judgement.

3.1.3 Lessons learned from the case study

Overall the case study confirmed that the assessment of cumulative effects is possible through a sequence of iterative steps involving initial issues identification based largely on available information, and subsequent analysis and validation of findings. The workshop, attended by knowledgeable participants, proved to be a highly effective tool for identifying stressors, the main issues relating to cumulative effects, and several major cause-effect linkages. The case study examined a wide range of stressors and potential effects, often qualitatively; the process would have benefitted from a more rigorous and formal scoping exercise in the early stages of the assessment, to focus the bulk of the analysis on those potential cumulative effects of greatest significance.

The case study also illustrated some of the challenges relating to the evaluation of the significance of cumulative effects, both for cultural and biophysical resources. Potential conflicts were avoided because overall goals were well established. For example, at Louisbourg commemorative integrity clearly takes precedence over ecological integrity; thus, corrective measures may be envisaged where ecological processes are leading to the destruction of valuable cultural resources. The preparation of both ecological and commemorative integrity statements will provide a forum for further defining site objectives, and will be invaluable to cumulative effects assessment. In general, then, the importance of clearly defined and widely supported management objectives, through tools such as management plans, regional official plans or regional planning studies, cannot be

underestimated. Above all the evaluation of significance requires a clearly defined endpoint for management. Many of the key issues highlighted the need for developing thresholds or guidelines to define acceptable levels of use in the face of incremental growth. The case study suggests that the development of such thresholds at the strategic level will provide essential guidance to decision making at the project level. This also illustrates the close links between strategic and project environmental assessments.

These lessons guided subsequent investigations into appropriate building blocks for a conceptual framework and approach for assessing cumulative effects. More specifically, they showed that a CEA framework must provide a forum for effective scoping of key components and indicators; it must consider key cause-effect linkages and focus on the major pathways of change; it must incorporate the use of endpoints to management and clear goals and targets as a baseline for evaluating overall change; it must provide some means of integrating new information into the process as it becomes available, and follow-up activities for feedback into a management/decision-making process.

3.2 ORGANIZING CONCEPTS

3.2.1 Sustainable development as a first principle for CEA

Since it was first coined and popularized in the 1980s (IUCN et al., 1980; WCED, 1987), the concept of sustainable development has provided a conceptual basis for exercises seeking

to balance short- and long-term imperatives. Despite the ambiguities inherent to the concept (Redclift, 1987; Robinson et al., 1990), principles of sustainable development have been developed which can provide direction to the implementation of sustainability (IUCN et al., 1991). Thus, sustainable development can provide the first principles for cumulative effects assessment. In the words of Cocklin et al. (1992a): “*Cumulative effects assessment presents a framework for analysis consistent with the concept of sustainable management. Or, looking at it from another perspective, sustainable development offers the broad objective towards which the management of cumulative change is directed.*”

Environmental assessment can therefore be seen as a tool which requires decision makers to understand the consequences of their choices on long-term sustainability, based on principles such as cross-generational and inter-generational equity in sharing finite resources (Sadler and Jacobs, 1990b; Beanlands, 1992). Conventional environmental assessment cannot achieve this without considering the cumulative effects of multiple activities (Cocklin, 1993); moreover, it must also address the broad strategic levels of decision making (WCED, 1987; MacNeill et al., 1991). It follows, therefore, that the new generation of EA can promote sustainable development and help avoid the “driving causes” of unsustainability (Sadler and Jacobs, 1990b).

However, environmental assessment in itself is not sufficient for achieving sustainable development (Munro, 1986; Wight, 1994), but must be combined with other supporting environmental management tools and techniques (Sadler and Jacobs, 1990a). Some of these

tools include environmental audits (Sadler and Jacobs, 1990a), state of the environment reporting (Cocklin and Parker 1991; Cocklin et al., 1992a; Sly, 1994), comprehensive land use planning (Richardson, 1989), and conservation strategies (IUCN et al., 1991). Because sustainable development provides the first principles for these other mechanisms, they will be mutually supportive and interconnected.

3.2.2 CEA as an ecosystem approach to environmental assessment

The term “ecosystem approach” has increasingly been used to refer to a cross-sectoral approach for comprehensive planning and management studies, usually involving the integration of biophysical, social and economic concerns and examining the interactions between these concerns and the biophysical environment (Barett and Kidd, 1991; CCME, 1996; Environment Canada, 1996). The concept of health has frequently been used as a common objective for the various parties involved in environmental planning or management studies. Through analogies with human health, the concept of ecosystem health is intuitively easy to understand, and is increasingly viewed as a prerequisite for human, community and economic health. For this reason, the ecosystem approach is usually linked to the concept of ecosystem health or integrity as endpoints for environmental management.

The ecosystem approach is generally recognized to focus on natural rather than institutional boundaries, adopting broader temporal and spatial scales, and considering a range of management issues rather than individual sectors integrating both science and management

(Environment Canada, 1996; CCME, 1996). The high levels of uncertainty brought about by the scope of the approach require the adoption of a flexible process that allows adaptations to be made based on ongoing feedback received. Emphasis is placed on multi-agency co-operation and the participation of multiple stakeholders (Barrett and Kidd, 1991). The approach often focuses on the development of clear goals and objectives, using indicators to measure achievement and orient monitoring.

Cumulative effects assessment that implements these components can thus be viewed as adopting the ecosystem approach (Bronson et al., 1991; Slocombe, 1994; Munn, 1994). The adaptive nature of the approach may be especially relevant to CEA, where high levels of uncertainty require stricter feedback and implementation of corrective measures if required (Horak et al., 1983; Hegmann and Yarranton, 1995).

3.2.3 Integrity as an endpoint for CEA

A growing discipline has emerged which focuses on studying, defining and describing ecosystem health and integrity (Rapport, 1995). Haskell et al. (1992) stress the importance of long-term protection of ecosystems as opposed to maximizing short-term goals, and argue that striving for ecosystem health provided a broader perspective which encompasses overall performance rather than single-species management, provided that health is adequately defined. Costanza (1992) defined integrity as the maintenance of system structure and functions over time, as well as its resilience to stress. Norton (1992) distinguished between

health and integrity and suggested that the first reflects effective functioning while the second refers to unimpaired conditions:

"Let us say that a system is healthy if it maintains its complexity and capacity for self-organization. An ecological system has maintained its integrity - a stronger concept that includes the conditions of health - if it retains (1) the total diversity of the system - the sum total of the species and associations that have held sway historically - and (2) the systematic organization which maintains that diversity, including, especially, the system's multiple layers of complexity through time."

Woodley (1993a) introduced the notion of optimal ecosystem development to reflect the subjective nature of the concept:

"Ecological integrity is defined as a state of ecosystem development that is optimized for its geographical location. For parks and protected areas, this optimal state has been referred to by such terms as natural, naturally evolving, pristine and untouched. It implies that ecosystem structures and functions are unimpaired by human-caused stresses, that native species are present at viable population levels and, within successional limits, that the system is likely to persist. Ecosystems with integrity do not exhibit the trends associated with stressed ecosystems. Parks and protected areas are parts of larger ecosystems and determination of integrity in national parks must consider these larger ecosystems."

While many of the studies of system integrity have been focused on ecosystems, the concept is broadly applicable. Within Parks Canada, the term commemorative integrity has been used in the context of historic sites to denote that the resources for which the site is being commemorated are not impaired or threatened, that the site's heritage values are being respected, and that the site's national importance is being effectively communicated (Parks Canada, 1994). Thus, the concept of integrity has come to connote wholeness, soundness and health. By providing an objective to strive for in the management of cumulative effects, integrity may be viewed as a context within which CEA may occur (Slocombe, 1994; Dias

and Chinery, 1994). This view was adopted by Sallenave (1994) in assessing the effects of multiple stressors in the Hudson Bay region, based on an analysis of the current state of the environment and the potential limits of the system.

3.2.4 Using indicators of integrity in support of CEA

Many of the approaches used to assess cumulative effects have incorporated the use of indicators (Shoemaker, 1994b; Doyle, 1994; Stevenson, 1994); indicators have also been used to define the concept of ecosystem integrity (Woodley, 1993a; Noss, 1995).

Environmental indicators have been defined as *“a characteristic of the environment that, when measured, quantifies the magnitude of stress, habitat characteristics, degree of exposure to the stressor, or degree of ecological response to the exposure”* (U.S. EPA, quoted by Alberti and Parker, 1991). Indicators may be used as surrogates when key components cannot be measured directly; for example, ecosystem integrity may be retained as a valued component but must be defined more precisely through the use of a suite of scale-sensitive indicators (Karr, 1992; Woodley 1993b; Slocombe 1994).

Several types of indicators have been recognized, including: 1) early warning of stressors; 2) exposure-oriented indicators; 3) stressor-linked indicators (focusing on effects); 4) “weakest link” indicators, focusing on the vulnerability of the system; 5) keystone species; 6) “negative indicator species”; 7) benchmarks or monitoring indicators, focusing on

baselines and trends; and 8) integrative sets of indicators, or sentinels, providing integrative information on overall health of a system.

Some species may be highly correlated with stresses in the environment and can therefore serve as an early warning (Orians, 1986; Regier, 1986). For example, honey bees have been used to indicate accumulation of pollutants in terrestrial environments (Cocklin et al., 1992a). The importance of developing an early-warning diagnosis of threats to ecosystems resilience, structure or function, has been emphasized (Rapport et al., 1985; Rapport, 1995).

Exposure-oriented indicators are perhaps among the best known and most used; examples include fecal coliform and total coliform counts as indicators of water quality. Stressor-linked indicators focus on effects. For example, if fragmentation of habitat has been identified as a cumulative effect of concern in an assessment, indicators of fragmentation, such as areas of unimpacted patches of vegetation, may be required to analyze trends over time.

Some species, such as top predators with very large ranges, may be vulnerable to stress because of their habitat requirements. For example, Gosselink and Lee (1989) found that the most sensitive species in the bottomland hardwood forests were those that were dependent on mature forests or those that required extensive home ranges. However, unusually sensitive species may not be representative of requirements of other species, and a range of indicators should be used (Orians, 1986; Cairns, 1986).

Keystone species are those that are considered essential to maintain ecosystem structure of function: their disappearance would entail the extinction of other species. Negative indicator species, such as coyotes or cowbirds, are non-native species whose presence may threaten native diversity (Gosselink and Lee, 1989). This category may also include indicators of ecosystem distress, such as smaller overall body size or increased leaching from terrestrial into aquatic habitats.

Indicators may be identified to set benchmarks for measuring cumulative effects over time: *“By using biological indicators in conjunction with reference or minimally impacted sites, investigators have described the baseline conditions of entire regions.”* (CEQ, 1996). Integrative information on the overall state of health of a system usually involves the selection of a range of indicators, perhaps combining indicators of all elements mentioned above. Disciplines such as landscape ecology can provide a broader-scale perspective of critical ecological processes such as habitat pattern, connectivity, and fragmentation to provide an overall view of ecosystem (CEQ, 1996). It is important to identify key ecosystem functions, even though assigning values to functions will be difficult to accomplish (Gartner et al., 1994). These indicators may be used in conjunction with techniques such as remote sensing or GIS to provide characterizations of trends over time (CEQ, 1996).

Indices are the result of several indicators that have been combined into a single measure: most are chemical in nature. The EPA defines indices as “mathematical aggregation of indicators or metrics” (Alberti and Parker, 1991). For example, an “Index of Biotic

Integrity” was used to evaluate overall stream water quality by aggregating twelve characteristics related to biodiversity, indicator species, biotic composition and productivity (Haskell et al., 1992; Karr, 1992). An “Index of Network Ascendancy” was developed to incorporate four ecosystem characteristics: species richness, niche specialization, developed cycling and feedback, and overall activity (Ulanowicz, 1992).

Some researchers have used indices of overall cumulative effects to help evaluate alternatives where difficult trade-offs are involved, but this has proved controversial (CEQ, 1996). Indices may involve assumptions and simplifications: biological information can be lost in the mathematical formulation, which can bias the results (Weller, 1988). Consequently, indices are seldom used in CEA (CEQ, 1996), and other techniques for appraising integrity have gained importance

3.3 THE CAUSE-EFFECT MODEL FOR CEA

3.3.1 Exploring the cause-effect model

The extent of the debates over cumulative effects is, perhaps, not surprising given the diverse nature of these effects, the variety of scales at which they accumulate, and the numerous contexts in which CEA must be applied. It would be unrealistic to expect to find a single model or method that can perform all the range of tasks required. This is borne out by facts: no single method exists, nor is there a universally accepted conceptual framework for CEA

(CEQ, 1996).

However, there appears to be a general consensus on the importance of identifying cause-effect linkages for assessing cumulative effects. Earlier generations of environmental assessment interpreted this model to mean that single, discrete *causes* could lead, more or less directly, to single, discrete, and often local effects (see Figure 4).

Figure 4
Basic cause-effect model

This model can be expanded to recognize that multiple stressors act upon the environment to produce overall effects (see Figure 5). These stressors may stem from different sources, such as past, present or future activities, including those that are local, regional or global. Stressors also include natural perturbations or catastrophes. These stressors act upon the system through various pathways or processes of intervention: frequently non-linear, pathways can involve interactions and synergies, and may involve time or space lags. The resulting effects will be determined by the overall response of the system to all stresses acting upon it. The response, which will shape the state of the environment, may occur at an ecosystem, landscape or global scale.

Figure 5
Cause-effect model for cumulative effects

A similar “input-output” model was proposed by Sonntag et al. (1987), based on three components: (1) activities as causative factors; (2) systems structure and processes of perturbation; and (3) the output, or cumulative effects, system process and cumulative impacts. Various adaptations of this systems model have since been proposed (Horak et al., 1983; Dickert and Tuttle, 1985; Lane et al., 1988; Contant and Wiggins, 1991; Spaling and Smit, 1993). Spaling (1993) bases his framework on an “*input-process-output model derived from systems theory and stress ecology*.” Cocklin et al. (1992a) stressed the three elements of the model as sources of change, pathway of accumulation, and impact accumulation. Thus, the delineation of cause-effect relationships between activities and ecosystem appears to be a fundamental component of cumulative effects theory (CEQ, 1996).

Implicit in this model, however, is the recognition that cause-effects do not represent linear relationships and that a reductionist approach cannot be adopted (Cocklin, 1993). Sly (1994)

recommends the development of cause-effect hypotheses, and Davies (1991) refers to “webs of causality”.

3.3.2 Evaluating the consequences of cumulative change

The CEA model described thus far consists of an analysis of cause-effect linkages and interrelationships. Evaluating the significance of the resulting changes is best viewed as a separate phase of the CEA process (Stakhiv, 1988). The endpoints to management obtained through the ecosystem approach and the concept of system integrity, and the objectives and targets associated with the selected key components and indicators, provide the tools required for evaluating the significance of change.

The state of the environment may be visualized as located along a continuum ranging from a stressed system to a state of integrity, which should be defined as precisely as possible for a given geographic area at a given scale. The actual position of the ecosystem along this continuum will be determined by the nature and quantity of stressors acting upon the system. Any new project or actions will result in the creation or elimination of stressors, thereby shifting the position of the environment along the continuum (see Figure 6).

Information provided from the cause-effect analysis, as well as the indicators and targets available, serves to predict the nature of this shift either towards or away from system integrity. The role of evaluation is therefore to establish whether the trends which emerge

from the analysis are acceptable, or whether specific modifications should be brought to the proposal.

Figure 6
Evaluation framework

This model of evaluation is useful for cumulative effects assessment since it provides an overall perspective of the entire ecosystem, and allows changes stemming from a specific proposal to be considered in terms of the context of overall human activities and environmental trends.

3.4 A CONCEPTUAL FRAMEWORK FOR ASSESSING CUMULATIVE EFFECTS

3.4.1 Building blocks

A conceptual framework for CEA is presented in Figure 7. It is designed, not as a prescriptive approach, but as a means of organizing relevant information into a flexible, manageable structure to better assess cumulative effects.

The conceptual framework is based on a cause-effect model for the analysis of cumulative effects. The central focus is the system or ecosystem. The framework represents a progression from an existing context, shaped by past actions, towards anticipated future changes brought about by a specific proposal. The evaluation of effects is undertaken separately based upon the determination of whether overall changes will move the system closer to or away from integrity. Integrated monitoring provides an opportunity for feedback linkages to the resource management processes and state of the parks reporting.

3.4.2 Framework flow

The conceptual framework is triggered by a *proposal*, which may be a plan, policy, programme or project. The potential impacts of that proposal will combine with the impacts of all past, present and known future actions including those which are local, regional or global in origin. The proposal may therefore change the overall combination of stressors

acting upon the environment. Decision makers must understand to what extent the potential impacts of the proposal will shift the current state of the environment in terms of the pre-established goals, so that they can determine whether the proposal is acceptable.

The analysis of the changes brought about by the new proposal will involve a study of the cause-effect linkages. This means that three elements must be analyzed: the stressors, the pathways of change, and the response of the environment to those stressors. Essentially, the changes brought about by the proposal will lead to a new state of the environment. This will shift the existing state of the environment along the continuum, either towards or away from environmental integrity. The evaluation involves understanding this new position in terms of existing overall objectives, targets or goals. This will provide the context for a decision, which can be a rejection of the proposal (or modification and re-assessment), or the acceptance of the proposal, with or without mitigation. When a proposal is accepted and implemented, all residual impacts become part of the existing stressors, and as such will need to be considered when the next proposal is evaluated.

The scale at which this analysis must occur will change depending upon the proposal involved and the scale of the potential cumulative effects. The analysis may therefore be very involved or fairly simple depending on the context.

When an analysis is first undertaken for a given heritage area, it will identify the various stressors acting upon the system and the resulting consequences on key components.

Subsequent environmental assessments will become easier to undertake as each one builds upon information obtained in the previous assessment and updated by integrated monitoring. To facilitate information exchange and feedback, information should be compiled within a single data base or document for each heritage area.

Both the analysis and evaluation will be subject to high levels of uncertainty. Integrated monitoring is an important component of this framework. Monitoring will occur for specific proposals as well as for overall environmental change. Information from the monitoring program will provide valuable input to the next proposal analysis.

3.4.3 Developing step-by-step guidance

The conceptual framework for assessing cumulative effects can essentially be expressed in terms of a series of iterative steps that can be incorporated into an environmental assessment. The tasks should be flexible, allowing practitioners to adapt the process to reflect various contexts and circumstances. The need for a plurality of approaches for CEA (Irwin and Rodes, 1992; Davies, 1992; Cocklin et al., 1993b; Spaling and Smit, 1993) can therefore be integrated into a practical, manageable process.

There are several examples of step-by-step guidance for implementing CEA (Davies, 1992; FEARO, 1993a; Doyle, 1994; Kalff, 1995; CEQ, 1996). In some cases, tasks may be outlined as successive options such as a decision tree (Lane et al., 1988) or as a series of

questions (Irwin and Rodes, 1992). The steps may include quantification techniques; for example, Duval and Vonk (1994) developed a multi-step procedure for semi-quantitative evaluations based on zone of influence of project and overlapping environmental components. While the steps may be combined in different ways, they generally include identifying appropriate scale and boundaries, scoping activities and effects, identifying stakeholders, establishing a context or baseline conditions, predicting impacts, defining thresholds, analyzing alternatives, identifying mitigation, evaluating significance, establishing monitoring requirements, determining uncertainties and trade-offs, preparing recommendations, documenting the assessment and providing feedback to other processes.

The use and limitations of EA techniques for CEA has been extensively documented and several typologies of CEA tools have been advanced (Cocklin et al., 1992b; Spaling, 1993; Hegmann, 1994; Shoemaker, 1994b). Both Lane et al. (1988) and the CEQ (1996) proposed that several alternative methods may be available for each of the steps involved in the CEA process. A “toolbox” approach has been promoted that provides a series of techniques which can be applied according to need based on the judgement and experience of the practitioner (Duval and Vonk, 1994; Hegmann and Yarranton, 1995).

3.5 CHAPTER CONCLUSIONS AND NEXT STEPS

This chapter has reviewed the major case study and the literature for lessons learned and organizing concepts. A conceptual framework has been proposed using an analysis based on

a cause-effect model: sources of stress resulting from past, present and known future projects and activities, combine through various pathways of change, to result in overall consequences that determine the ultimate state of the environment. The significance of introducing new sources of stress into the system can then be evaluated based on whether the anticipated overall changes will move the system closer to or away from environmental integrity. Monitoring and feedback have been identified as integral components of the framework.

This framework will be most relevant to EA practitioners when translated into a detailed approach that outlines the various steps involved. The next chapter therefore provides step-by-step guidelines to implement the conceptual framework for CEA, incorporating examples of methods and techniques in the various steps as required.

CHAPTER 4

INTERPRETING THE FRAMEWORK: A STEP-BY STEP GUIDE

4.1 SCOPING

Scoping is a first-cut identification of the boundaries and key issues of an environmental assessment. It is an iterative process: as the assessment proceeds, adjustments can be made, new issues can be included in the assessment, or boundaries can be expanded as required. Effective scoping is difficult, since the significance of issues must be approximated to distinguish between what is critical and what is unimportant. Failure to eliminate insignificant issues is a frequent problem in scoping (Gilpin, 1995) and can lead to an inefficient and unmanageable environmental assessment. Scoping is all the more critical in cumulative effects assessment because of the complexities of modeling cause and effect based on expanded scales, multiple causes and non-linear pathways. The successful implementation of CEA rests, to a large extent, on the ability of practitioners to “count what counts” (CEQ, 1996).

Orians (1986) argues that if the adage that “everything is related to everything else” were true in a literal sense, CEA would not be manageable: *“Our chances for success rest upon the fact (or hope) that the number of strong connections upon which we need to concentrate our attention is a small enough number to be manageable, and that our insights will enable us*

to recognize which ones they are.” Thus, the key to success lies in the identification of the most relevant linkages (Dayton, 1986; Dixon and Montz, 1995; Hegmann, 1994; Hegmann and Yarranton, 1995; CEQ, 1996).

The first step in terms of CEA is to determine whether the potential for cumulative interactions exists. The practitioner should consider whether the potential impacts of the proposal, along with other existing or known future stressors, could

- ❖ occur so closely together over time that the recovery of the system is exceeded;
- ❖ occur within a given geographical area, so closely together that their effects overlap;
- ❖ interact among themselves, either additively or synergistically;
- ❖ affect the same key components of the environment, directly, indirectly or through some complex pathway;
- ❖ accumulate through insignificant increments; this may happen if the proposal is one of many of the same type, producing impacts that are individually insignificant but that affect the environment in a way that they can become collectively important over the longer term (nibbling effect).

In the affirmative, it may be concluded that the potential for cumulative effects exists and should be further investigated. In the last case, where a large number of small projects that are similar in nature lead to individually unimportant effects that may be collectively significant, they are best grouped together and assessed as a class.

4.1.1 Scoping the policy context

Reviewing the policy context of a proposal is a useful task in the scoping exercise, especially for strategic EAs. It involves considering the fundamental purpose, overall goals or anticipated outcomes of the proposal under review, to ensure that there are no inconsistencies in the policy context (Leung, 1985). Previously unrecognized policy contradictions may come to light while examining the environmental implications of a proposal. It is not the purpose of environmental assessments to resolve fundamental policy inconsistencies. Where they occur, they should be referred to an appropriate forum for resolution prior to the commencement of the environmental assessment. Delay would likely be inevitable in such cases but would be minimized by resolving conflicts early in the process, rather than risk revisiting decisions after investing resources in the proposal development.

The links between policy, plan and project levels of decision making are usually very direct. Many cumulative effects originate from policy, and related mitigation, such as defining suitable thresholds or limits, is best addressed at such levels. Failure to do so will broaden the scale of project-level assessments in an attempt to deal with unresolved strategic issues.

4.1.2 Scoping issues and concerns

Assessing cumulative effects usually broadens the scope of the EA: as a result, cumulative effects assessment may appear open-ended, and it is important to ensure that the scope of the

assessment remains manageable while addressing the important issues that must be assessed. The challenge lies in determining how far to go. The importance of potential cumulative effects is not necessarily proportional to the size of a project. Small, local projects must be considered in terms of the broader region or ecosystem in which they are located. How will they affect overall integrity? What other sources of stress currently exist and how would the project add to this existing situation? In some cases, even potentially insignificant impacts that could result from the project under review may need to be retained in the scoping exercise because of the potential overall cumulative effects.

To help identify which issues warrant close attention and which ones are less important, a valuable rule of thumb is to consider the probable scale and severity of the cumulative effects. How extensive are the potential impacts? For example, shoreline modifications occurring along a historic canal may be widespread or spatially limited. The practitioner should consider what overall percentage of shoreline is being affected, and whether limits have been identified from a strategic perspective such as a management plan or integrity statement. The scale and severity of the potential cumulative impacts can thus guide the scope of the assessment.

In the absence of overall policy direction, this approach may lead to an assessment that is much broader than the scope of the decision under review. For example, when a long-term development plan for a commercial ski area within a national park addresses fundamental issues such as appropriate limits to use, all projects stemming from that plan can be assessed

much more effectively. On the other hand, if overall levels of use have not been explicitly identified at the strategic levels, individual proposals such as parking lot expansions or new ski lift construction will raise questions regarding adverse effects relating to incremental rises in use. Project level assessments can become unmanageable if used as a forum for addressing such broad issues, but practitioners may have little choice in such circumstances if cumulative effects are to be assessed.

The questions of inducing future growth or creating a precedent that will lead to further projects are important ones for cumulative effects, especially in heritage areas. Thus, future growth that is linked to the proposal at hand must be addressed in cumulative effect assessments (Davies, 1992; Kalff, 1996).

There are several effective techniques for scoping issues. Existing documentation, such as management plans and integrity statements, often provides a clear indication of key concerns within a heritage area. Past environmental assessments can also be valuable. Workshops with key stakeholders are highly effective for scoping issues.

4.1.3 Identifying key environmental components

Not every aspect of the environment can be measured; an assessment must focus on key attributes. The use of *valued ecosystem components*, or VECs, has been common practice in EA since the 1980s (Beanlands and Duinker, 1983). VECs have been defined as

components of the environment that have intrinsic value to humans or to ecosystem integrity (Lane et al., 1988). In practice, scoping exercises have often identified long lists of VECs, failing to eliminate components due to the perception that failure to make the list means the component is “not valued”. The use of the term “key component” rather than VEC can help eliminate this concern.

Key components may be single species, a system of interacting species, entire ecosystems, or specific ecosystem functions or properties (Orians, 1986; Irwin and Rodes, 1992); they should be chosen to best suit the concerns of each assessment. The selection of appropriate key components is critical since variables selected can influence the way issues are perceived and solutions developed (Alberti and Parker, 1991). Key components are also scale-specific: components selected at a local scale may not be easily adapted to an ecosystem level. The local scale will often concentrate on individuals, while a broader-based ecosystem scale will consider communities or populations (Beanlands and Duinker, 1983). The components selected will also provide insight into appropriate boundaries for the assessment (Irwin and Rodes, 1992).

Not all key components can be measured directly. In some cases indicators can be used as proxies to provide information on key components. The selection of indicators must be undertaken carefully, based on factors such as scientific validity, ease of measurement, and cost of monitoring (see Table 4). Indicators selected must present sufficient information concerning the component of interest to conduct an analysis that is meaningful to the

assessment: it would not be appropriate to select an indicator about which nothing can be determined (NEB and CEAA, 1996). Sonntag et al. (1987) observed that cumulative effects assessments are more advanced in fields where a greater consensus exists over appropriate parameters and indicators. However, the ecological information that can be inferred from widely-accepted chemical indicators may still require validation (Orians, 1986).

Key components and indicators may be more effective when associated with quantitative or qualitative targets in assisting the evaluation process by providing a baseline against which change can be measured. Targets may consist of established standards or norms, or they may be programme-specific objectives such as the aim to achieve 50% reduction in solid waste production (Gaudet et al., 1997). An adaptive selection process is required, and components selected may need to be revisited should goals be clarified (Rennick, 1994).

Key components must relate to the issues of concern identified in the scoping; this is why, in the context of environmental assessments, key components are often linked to stressors. Where a particular source of stress is understood, early warning indicators of environmental stress can be helpful in showing how close the system is to achieving a target or reaching a threshold. To adequately reflect system integrity, a range of indicators should be selected representing ecosystem structure and function over appropriate scales, customized for each ecosystem type and circumstances (Haskell et al., 1992; Woodley, 1993a). The criteria established in Table 4 can be helpful in the selection of a workable suite of key components.

Table 4
Selection criteria for key components (adapted from Woodley, 1993a)

In selecting a set of key components for assessing cumulative effects, consider including key components that:

- ❖ represent a broad range of species and ecological functions over scales that are appropriate to the assessment in question
- ❖ represent a range of successional stages and reflect our understanding of the dynamic nature of the ecosystem
- ❖ represent a range of conditions (i.e. from natural to stressed conditions)
- ❖ reflect specific objectives or goals of the heritage area
- ❖ relate to known stressors that are cumulative in nature
- ❖ relate to the ecosystem and not to jurisdictional boundaries

Examples of key components to be included:

- ❖ species with large body size or large territory requirements
- ❖ old-growth or benchmark species
- ❖ early-warning or vulnerable species
- ❖ rare species
- ❖ dominant species such as top predators or keystone species
- ❖ exotic or non-native species living in the heritage areas
- ❖ species that accumulate or biomagnify toxins

Indicators selected should be:

- ❖ relatively easy to measure
- ❖ scientifically valid
- ❖ present a high signal/noise ratio

Key components and indicators will often be identified in documents such as ecological or commemorative integrity statements. Pertinent information may also be available from resource management plans, ecosystem management plans, resource management plans, past or current monitoring programs or the literature. The scoping exercise should focus on selecting the most appropriate set of components to address the key issues. For example, in the cumulative effects assessment of the Niagara Escarpment Area, issues identified in a scoping exercise were linked to monitoring questions for which indicators and corresponding targets were established (Rennick, 1994; MacViro Consultants Inc., 1995). The Bruce Peninsula Case Study followed this model (Geomatics International, 1996b). Achieving a

balanced suite of components and indicators is a challenge that is well worth the effort. If the list is too long, it defies effective analysis, yet if too few are selected some issues may not be adequately reflected in the analysis.

4.1.4 Determining the appropriate scale

Cumulative effects have been overlooked in the past because scales used were inappropriate, especially for project assessments. Undoubtedly, one of the reasons for this is the perceived open-ended nature of assessing broader-scale issues. Effective scoping must establish appropriate scales and boundaries, broad enough to include cumulative effects but not so broad that the assessment becomes unmanageable. As a rule of thumb, the scale of the assessment should match the scale of the overall potential cumulative effects, bringing into focus the broad patterns that are key to CEA. The nature of the issues and key components thus provide guidance in selecting the appropriate scale.

More specifically, factors to consider in identifying appropriate spatial scales include: (1) the goals of the assessment; (2) the extent of disturbance; (3) the location of other contributing stressors; (4) ecological considerations, such as watershed boundaries or habitat of far-ranging species; and (5) technical, administrative or project-related considerations. Consideration of these factors generally involves a first-cut scoping exercise to identify potential issues and key components affected, perhaps adopting different perspectives.

Firstly, the goals of the assessment will provide fundamental guidance for the selection of scales. Norton (1992) concluded that appropriate scale is largely a function of social values and goals rather than scientific criteria: *"...the apparently limitless number of possible hierarchical models of natural systems will be sorted out according to their usefulness in clarifying, explaining and achieving public goals. The correct scale on which to address a management problem is determined by what society wants to accomplish with the system."*

Secondly, spatial boundaries should reflect the extent of potential overall disturbance. This should include the geographical area used by all species found within the primary impact zone of a project (Bedford and Preston, 1988).

The third factor to consider in the selection of scales is the spatial distribution of contributing stressors. Sonntag et al. (1987) expressed this as the question: *"What is the largest geographical extent over which these activities will occur?"*. Many practitioners prefer to consider issues from a landscape or regional perspective, to identify broad patterns (Gosselink and Lee, 1989). It may be advisable to first consider the potential effects from a broader perspective before taking a narrower view. As Young (1986) expressed it, *"If we work on the correct spatial scale, the 'forest', then we can resolve conflicts at the level of the 'individual tree'."* Different patterns may be detected by adopting different perspectives; for example, in their work on the cumulative effects of oil fields in Prudhoe Bay, Alaska, Walker and Walker (1991) identified completely different series of disturbances corresponding to different scales ranging from the site-specific to global.

The fourth factor to address is ecological considerations. Natural boundaries can provide an effective framework for assessing cumulative effects (Beanlands and Duinker, 1983). However, ecosystems themselves are hierarchical and the selection of appropriate ecosystem boundaries may depend on the requirements and interactions of the key components in the assessment. Watersheds are frequently used ecological boundaries (Irwin and Rodes, 1992), particularly when aquatic components are of interest, because their boundaries are fairly discrete. "Airsheds" have been used to describe the space in which pollutants may migrate within the atmosphere, and to illustrate that the atmosphere is a "leaky box" (Munn, 1986). Gosselink and Lee (1989) extended this concept further: "*It might be more appropriate to speak of wolf-sheds or bear-sheds when considering the cumulative effects of forest clearing on large mammals*". This emphasizes that wide-ranging species are especially sensitive to fragmentation of habitat and boundaries established should reflect the full range of their needs (Harris, 1988). Concern over migratory species such as birds or monarch butterflies may require the definition of boundaries over non-contiguous areas (Irwin and Rodes, 1992).

It may be appropriate to focus on the most vulnerable species within an ecosystem, such as wide-ranging top predators, to ensure that a large enough study area gets defined. Scales selected must also encompass natural variations in functions (Norton, 1992). The calculation of *minimum viable areas* for keystone species or large carnivores (Soulé, 1987) provides an indication of spatial boundaries required for the likely survival of a population over a given number of years. Such calculations have demonstrated that the world's parks and reserves are invariably too small to support populations of wide-ranging species in the long term

(Woodley, 1993a). The selection of appropriate boundaries therefore requires at least a preliminary understanding of potential effects and ecological processes and functions (Preston and Bedford, 1988; Irwin and Rodes, 1992).

The final factor in establishing boundaries involves practical considerations relating to jurisdictions and administration, as well as aspects relating to the project itself or to technical considerations. For example, selection of an entire watershed may not be practical because of the huge area involved, especially if the major concerns relate only to one section of the watershed. It may be impossible to ignore jurisdictional boundaries because of data limitations or the lack of common goals. It may also be appropriate to identify several different spatial boundaries for the different components considered in the assessment.

Just as the extent of spatial boundaries influences the detection of patterns of change, the time scale considered can alter perception of cumulative effects. Peterson et al. (1987) illustrated this point using the example of the gradual addition of contaminants to groundwater. In the short term, the additive effects would most likely be insignificant. However, when the groundwater eventually reaches discharge sites the effects can multiply as contaminants are released into the biological system. A whole new perspective is provided as a result of the longer time scales.

The selection of temporal scales involves many of the same considerations as for spatial boundaries, and should be undertaken as part of the same exercise within the context of the

initial scoping. To establish appropriate temporal scales for an assessment, it is necessary to consider (1) the lifespan of key components and potential duration of an impact; (2) time lags and synergies; (3) the recovery time of the system; (4) natural cycles and trends; (5) future actions that are reasonably foreseeable; and (6) practical considerations such as data availability.

The starting point for selecting temporal scales involves the duration of the activity being assessed. Sonntag et al. (1987) phrased this as a question: "*What is the longest period of time over which the activities are to be considered? This should include construction, start-up, operation, shut-down and decommissioning where appropriate.*" For example, if activities will extend over five years, this is the minimum period that must be retained for analysis.

The potential duration of the resulting effects will be a factor of the lifespan of components affected. For example, Clark (1986) considered the atmospheric lifetimes of various chemicals constituents to determine their potential for migration and accumulation. This time frame will be extended by interactions with existing and future actions, time lags and synergies (CEQ, 1996)

Thus, the second element to consider is the potential for time lags or synergies. Time lags occur when there is a delay between the accumulation of stressors and the onset of the adverse effects, usually when a threshold is exceeded. For example, increased acidification can change a soil's capacity to bind toxic metals, resulting in "chemical time bombs" that can

release a sudden influx of metals into the biological system, even when the original source of contamination has been removed (Stigliani, 1988). Similarly, effects such as erosion can accumulate gradually without apparent consequences until triggered by a large-scale, low-frequency natural event such as a flood, storm or earthquake (Dickert and Tuttle, 1985).

The recovery time of the system is the third factor to consider. This is critical since the inability of a system to recover from a perturbation is what leads to the accumulation of impacts. Recovery times are seldom known (Duval and Vonk, 1994) although Beanlands (1992) suggests that systems may take as long to recover from the removal of stressors as it took for them to degrade, and notes that "recovery is also a cumulative effect".

Cycles and variations occur frequently in nature and represent the fourth factor to consider in establishing temporal scales. Such fluctuations must be recognized and a broad enough time span must be identified in order to take these fluctuations into account. For example, Peterson et al. (1987) suggest that time spans of 30-40 years must be considered to understand the regular cyclic fluctuations of wolf and moose populations; Holling (in Woodley, 1993a) suggests that time horizons of 200 years are required for effective understanding and management of spruce budworms. Cairns (1986) notes that such fluctuations may often be erroneously attributed to stress.

The fifth factor to consider is future projects or activities that could affect the systems under review. It is necessary to consider future activities to obtain a realistic view of the total

stresses acting upon the area in the medium to long term (Irwin and Rodes, 1992). This is especially vital in areas where stresses may be approaching critical thresholds, since the approval of a project means excluding future options. In the words of Glaholt (1994), society then gives "tacit approval to relegating future generations to an environment that occurs more by default than by design".

The identification of future projects can be very difficult, especially with private proponents. FEARO (1993a) suggests considering only approved or imminent future projects. However, this is clearly insufficient in many cases; for example, projects identified in regional municipal plans are not usually approved until just prior to implementation, yet clearly signify an intent to proceed at some point in the future. The CEQ (1996) places greater emphasis on professional judgement by proposing the inclusion of "reasonably foreseeable" projects while eliminating those that may be considered "highly speculative". Growth-inducing potential must also be factored into the analysis (Contant and Wiggins, 1991; Davies, 1992). Precedent-setting activities are key contributors to potential future growth (CEARC, 1988). Certain key socio-economic activities, called "driving variables", may be strongly associated with the generation of other related activities (CEQ, 1996).

Finally, it is important to select practical temporal scales. For example, the CEQ (1996) recognizes that temporal boundaries may be defined, in part, by data availability, resulting in qualification rather than quantification in the analysis.

4.2 ANALYSIS

The analysis identifies sources of stress, pathways of change and, ultimately, the overall effects and state of the environment that result from these changes. There are two fairly distinct steps to the analysis. The first relates to the resource base itself and involves studying existing cause-effect relationships to understand how they shape the current state of the environment (the existing cumulative effects context). The second relates to the specific proposal under review and involves studying how the potential impacts of the proposal would interact within the existing context to bring about a changed state of the environment.

Once the first part of the analysis, the existing cause-effects relationship, has been completed, it will provide the needed cumulative effects context for the environmental assessments of any future proposals within the heritage area, as long as it is maintained and updated on a regular basis. This context may be developed through an initial study, or may be built gradually from information obtained through a series of studies, supplemented by existing documentation, such as heritage area management plans and integrity statements.

Ideally, quantified information is generated in the analysis. However, some issues defy quantification, at least with existing knowledge, and the analysis must rest upon best available information and best professional judgement.

4.2.1 Identifying the sources of stress

The identification of sources of cumulative effects is the first factor in delineating causality. Sources have been characterized by the number, type, extent or frequency of occurrence of human-induced activities (Spaling and Smit, 1993).

Orians (1986) considered sources of cumulative effects in terms of persistent additions or removal of material in the environment. Sources that lend themselves more easily to quantification, such as the addition of pollutants into the environment, have received greater attention than those that are more difficult to measure, such as the introduction or elimination of species (Orians, 1986).

Sonntag et al. (1987) considered sources in terms of single, multiple or global activities. Cocklin et al. (1992a) concluded that multiple sources are much more prevalent than single sources and include small actions and decisions usually outside the realm of EA. Lane et al. (1988) recognized that sources can include natural events or catastrophes, and that some sources of effects will remain unknown.

The ecosystem integrity approach adopts a medical analogy to view agents of change as stressors acting upon the environment (Rapport, 1992; Okrainetz, 1994). Stress may be part of the natural systems dynamics; however, human agents of change often induce adverse stress. Thus, all past, present and known future projects and activities within a given area

would constitute an overall stress load acting upon a system. Stressors would include local projects or activities, such as shoreline modifications, regional-scale activities, such as transportation corridors or contaminants added to a watershed, and global considerations, such as airborne pollutants or global warming (Sly, 1994; CEQ, 1996).

Natural sources of perturbation will affect ecological carrying capacity and must be considered when determining critical thresholds. Natural sources of stress may lead to undesired impacts, for example through the gradual destruction of cultural resources (Hems, 1996; Kalf, 1996). Natural sources of stress may include ongoing events such as erosion by wave action or wind, cyclic events such as fluctuations in faunal population levels, and catastrophic events such as major floods, forest fires or insect infestations. One of the challenges in cumulative effects assessment may be to differentiate between natural levels of stress and those additional stresses brought about by human activity. For example, in their regional assessment of cumulative effects in the bottomland hardwood forests, Gosselink and Lee (1989) analyzed the effects of incremental physical modification of a river and its floodplain to determine how such activities modified the natural hydrological regime.

Potential sources of information on past and present projects and activities include:

- ❖ workshops with key stakeholders, including scientific/technical staff;
- ❖ existing documents, such as ecological or commemorative integrity statements, management plans, conservation plans, site plans, development plans and so on;

- ❖ park or site records, including EA files and records, realty transaction files, past management plans or service plans;
- ❖ aerial photographs;
- ❖ historical maps or records or documents that record past activities;
- ❖ consultation with local associations and municipalities;
- ❖ records from other departments or levels of government, such as hunting or trapping records from provincial departments, or information on flooding histories from conservation authorities.

When the review of past and present actions reveals that many other proposals of a similar nature have been or will be advanced, it is preferable to group them into a single assessment.

Future projects or activities other than the proposal under consideration must be included in the analysis even though they do not contribute to the *existing* load of stress. Such future proposals are not being assessed in themselves; however, their effects should be considered as a “development profile” (Davies, 1992) to gain a complete picture of all stressors likely to act upon the environment. The assessment should therefore include future proposals that are “reasonably foreseeable” (CEQ, 1996), and may include approved or likely proposals, important or high priority projects, and possible events that present a reasonable likelihood of occurrence.

Some proposals, such as pre-approved projects and activities, are fairly certain to be

implemented in the near future. Since their effects will soon combine with all the other stressors acting upon the system, it is important to include them within the current context, especially when specific limits or thresholds are involved. Similarly, it is important to include projects or activities that may not yet have been approved, but that have a reasonable chance of occurring. This is a common-sense judgement call but it is important to remember the precautionary principle.

Anticipated projects or activities that are of great importance or high priority should be considered, especially where they have been included in proposed or approved planning documents such as municipal or management plans. This is because decisions taken today may foreclose future options: a decision about a project today necessarily affects the environment's ability to absorb impacts from future projects. The proposal currently being assessed may bring the overall levels of stress close to the limits of what is acceptable, so that implementing future projects with similar effects will become unacceptable without important and perhaps costly mitigation or remediation.

Unplanned events such as accidents or natural catastrophes are another category of potential future sources of stress that can act upon the environment (Lane et al., 1988). While such events obviously cannot be anticipated, the proposal of future high-risk projects or activities may warrant investigation into the likelihood of accidents. On a similar note, where key components may be approaching critical thresholds, it may be wise to incorporate into the analysis the possibility of natural events such as floods or droughts. Kalff (1996) examined

the possibility of oils spills as a result of the proximity of the Fortress of Louisbourg to major shipping lanes, but did not retain this as a factor in the analysis of cumulative effects since it was judged as an unlikely event.

There is a fine line to be drawn between known or anticipated future projects (as described above) and projects that will be engendered by the proposal under review. The latter, known as “future growth potential”, are definitely part of the equation in assessing cumulative effects (Davies, 1992; CEQ, 1996); however, they should not be considered part of the existing load of stressors. The potential for future growth associated with a proposal is best assessed as part of the impacts of that proposal: they are part and parcel of the proposal’s contribution to the total load of stress acting upon the system.

Sources of information on future projects and activities include:

- ❖ any land use plans describing future orientations, such as management plans, service plans, municipal plans, regional official plans or development plans;
- ❖ consultation with key stakeholders including planners, park managers, local municipal offices and municipal staff;
- ❖ in some cases, consultations with private landowners adjacent to the heritage area.

4.2.2 Identifying relevant pathways

The second element in the cause-effect model is the *pathway of change*, which provides

insight into *how* the sources of cumulative effects ultimately lead to the actual impacts observed. Only when such pathways are understood is it possible to identify, with any level of accuracy, the potential consequences of proposals, the likely severity of effects, and potential mitigation methods (Orians, 1986; Clark, 1986; Peterson et al., 1987; Cada and Hunsaker, 1990). This more than any other reason is a compelling argument for examining the pathways of cumulative change.

Just as sources of cumulative effects may be viewed in terms of single or multiple agents of change, pathways can be considered in terms of additive or synergistic processes (Peterson et al., 1987). *Additive pathways* are the result of the persistent addition or removal of material at a rate greater than ecosystem resilience. Such additive pathways have been described as “linear” or “additive/crowding” (Cocklin, 1993). *Synergistic (or compounding) pathways* occur when the initial addition or removal of material creates a chain of interacting events, ultimately resulting in an overall impact that is greater than the sum of the individual contributing effects. Such pathways have been described as “complex, non-linear” (Cocklin, 1993).

Peterson et al. (1987) further subdivided these categories based on whether single or multiple stressors triggered the processes, thus creating four categories of pathways. A persistent single source can result in an additive pathway (Pathway 1), or magnification (Pathway 2). Two or more stressors can result in multiple additive pathways (Pathway 3) or multiple synergism (Pathway 4).

The simplest pathway of accumulation is described as Pathway 1: the additive effects resulting from a single repetitive source that accumulate beyond the recovery rate of the ecosystem. Cocklin et al. (1992a) have characterized this pathway as the accumulation of effects. Repeated harvesting of furbearers or waterfowl is an example of an additive process; however, should a critical threshold be exceeded, the pathway may become non-linear (Harris, 1988).

Multiple sources may also lead to an additive, non-interactive effect (Pathway 3). Clark (1986) termed this “impacts cumulative in kind” or “different sources imposing similar consequences on valued ecosystem components”. An example is the non-synergistic occurrence of carbon dioxide and chlorofluorocarbons in the atmosphere, both of which affect atmospheric temperatures but through different, non-interactive processes (Peterson et al., 1987).

Synergism occurs when the resulting effect is greater than the sum of the individual sources. Compounding effects may result from a single source or multiple sources. The bio-magnification of DDT and its subsequent breakdown of steroid hormones in predatory birds, leading to the formation of thin eggshells, is an example of a Pathway 2 (Peterson et al., 1987). Photochemical smog provides an illustration of Pathway 4; nitrogen oxides and hydrocarbons stemming from multiple sources are considered more toxic in the presence of sunlight (Peterson et al., 1987).

Such categories, however, are not mutually exclusive. Pathways may function simultaneously, or may become non-linear after a critical threshold is reached (Peterson et al., 1987; Stigliani et al., 1991; Spaling and Smit, 1993). Sonntag et al. (1987) called such switches from linear to non-linear behavior “discontinuous”, and also identified “structural surprises” or pathways that are masked until a sudden intensity is reached. An additional pathway of change can occur through “countervailing effects”. This pathway has been defined by the CEQ (1996) as the overall effects that are less significant than the sum of individual effects.

Matrices can be used to record pathways; however, they have their limitations, since they cannot always illustrate the complexity of some of the linkages involved. Clark (1986) used a series of four matrices to establish pathways for cumulative atmospheric effects. He linked sources to impacts, established the relative importance of those sources and identified possible interactions between sources, and then prepared a synoptic matrix showing the relative impact of each source on key atmospheric components.

Network diagrams have also been used successfully to map pathways of change. Network diagrams involve sketching the links between the original source of the impact and the various interactions in the environment. Figure 8, from Heggman (1995), illustrates wildlife effects linkages.

Figure 8
Example of a network diagram
 (from Heggman, 1995)

4.2.3 Identifying the response of the environment

The response of the environment to the stressors acting upon it will determine the extent and magnitudes of the cumulative effects (Baskerville, 1986; Spaling and Smit, 1993; CEQ, 1996). That response is a function of the nature of the system (i.e. aquatic, terrestrial), its level of organization (i.e. transitional forest, mature forest), its complexity, as well as its original state of health, its resilience and stability, and the scales being considered (Spaling and Smit, 1993). The stability of an ecosystem refers to its degree of fluctuation around a steady state, while resilience refers to the ability of systems to “*bounce back or recover their original trajectory and rate of change relatively quickly after a perturbation*” (Noss, 1995).

While a system may have several responses to a single stressor (Duinker, 1994), in order to assess cumulative effects these responses should be considered from a holistic perspective, rather than attempting to add the effects of individual impacts (Roots, 1986; Cocklin et al., 1992a). Recent work in assessing ecosystem integrity, based on the development of indicators of overall integrity, provides the best means of characterizing overall system response. Okrainetz (1994) likens CEA to the health-diagnosis model: *"A cumulative effects assessment can be seen as a method of diagnosing the health of a patient who has been subjected to many different potentially harmful substances, and assessing the extent to which the patient can be further exposed before irreversible damage occurs."*

Ecosystem response to distress intensifies with the extent of stress, and may range from alarm, coping mechanisms to system breakdown (Rapport, 1992). Kay (1991b) proposed a framework for describing ecosystem response to stress based on fluctuations around an optimum operating point.

Because symptoms of ecosystem breakdown are measurable, the health-diagnosis model has led to the identification of general syndromes of environmental disease. These have been called "General Degradation Syndrome" or GDS (Regier, 1986) or Ecosystem Degradation Syndrome (EDS).

The symptoms of degradation include (Rapport et al., 1985; Regier, 1986; Sallenave, 1994):

- a decrease in size of organisms;
- a loss of species richness and diversity;
- the alteration of species composition to favor shorter-lived species;
- an increase in the incidence of disease;
- a decrease in the stability of component populations;
- an increase in the circulation and bio-accumulation of contaminants;
- changes in nutrient cycling, including increased leaching from terrestrial to aquatic environments;
- changes in primary productivity; and
- greater system fluctuations.

System response may change over time, either gradually or suddenly, after a “time lag”. For example, it was shown that the levels of mercury in Swedish lakes continued to increase even though mercury emissions from industrial sources had decreased significantly for two decades. This was linked to changes in the buffering capacities of soils and sediments as they were exposed to increasing acidity: the soils were no longer able to retain contaminants they had accumulated over 20 years ago (Stigliani, 1988). Similarly, “space lags” can affect environmental trends. Global impacts, such as the effects of acid rain, global warming or ozone depletion, will alter the response of local systems and must be factored into the equation.

The response of key components to the trends acting upon them must be considered in terms

of established goals for the heritage areas in question. In historic sites, natural ecosystem functions can exacerbate human-induced stress, causing a cumulative degradation of key resources. This was the case in Louisbourg, for example, where archaeological vestiges of the 18th century siege camp are being gradually destroyed as the relatively short-lived trees in the surrounding spruce forest die and are uprooted (Kalf, 1996).

The response of the system to overall stresses can be established by analyzing how key components change over time. Critical elements to consider include the rate of change, overall vulnerability and potential for reaching critical thresholds or limits. Matrices are very practical, workable tools for summarizing the response of the environment to stressors. For each specific key component, a matrix can show the various sources of stress, the main pathways involved and the resulting overall trends such as gradual loss of habitat, increasing fragmentation, or population fluctuations. GIS techniques can also be very useful to establish trends, mapping changes over time.

4.2.4 Predicting how the proposal changes the existing context

Once the context has been established for a given area - that is, all relevant sources of stress, pathways and trends are understood as well as possible - the analysis must focus on the relative contribution of the proposal to this overall context. How will the proposal change the environment? To what extent does the proposal exacerbate or mitigate existing stressors? What and how does the proposal contribute to the overall trends established for key

components?

The analysis must consider both direct and indirect effects of the proposal under review, as well as growth-inducing potential. Where several alternatives are proposed for a project, the potential implications of each alternative in terms of the overall context must be considered. It may be appropriate in some cases to include as an alternative the “no-go” option, that is, the implications of not going ahead with the project, as well as the alternative of re-examining current land uses. For example, in the EA of the proposed twinning of the Trans Canada Highway in Banff National Park a series of matrices was developed to assess the relative contribution of past actions to overall environmental response. It was concluded that the main contributors to overall cumulative effects were the existing highway, townsites, and transportation corridors: the additional impacts brought about by the twinning were similar to those caused by increased traffic under the “no-build” option (Department of Canadian Heritage, 1995).

In most cases it will be possible to establish the relative contribution of the project to the overall stress load by focusing on changes to existing trends. Existing data on key components and past experience, coupled with expert opinion where necessary, can lead to reasonable predictions. In Kluane National Park Reserve, the response of key components to the various stresses acting upon them was presented as a series of hypotheses which were then each examined in greater detail (Hegmann, 1995).

Predictions are extremely difficult to make in cumulative effects analysis. GIS techniques may be useful to track past changes and current trends which can then be extended to consider future projections. In some cases computer models have been developed to predict potential effects relating to a specific species. For example, the Yellowstone Cumulative Effects Model for Grizzly Bear management was developed to quantify the consequences of land use and activities on grizzly bears through vegetation mapping and the digitization of habitat components and human activities. The model is intended to enhance decision making by providing managers with a computerized tool to simulate cumulative effects of various potential land uses (Weaver et al., 1987). Follow-up is always important to validate predictions and to update analyses.

4.2.5 Identifying mitigation

Mitigation of cumulative effects presents some particular challenges that are not encountered in a more conventional approach to EA. Obviously, mitigation will most often be directed towards the project under review and those potential impacts that contribute to overall stresses. In some cases, however, mitigation can also be applied to other projects that affect the same key components, so that the overall effect will be reduced. In this sense, rehabilitation or restoration may be considered as mitigation of past impacts. Rehabilitation may reduce the overall effects to such an extent that a given project becomes acceptable. For example, in Point Pelee National Park, high levels of visitation within a small spatial area led to erosion and loss of vegetation. Mitigation included the preparation of an overall trail

plan leading to the closure of unofficial trails, the rehabilitation of damaged areas, the designation of capacities for trail use, and the development of strategies to disperse visitors to nearby provincial and municipal parks (Bill Stephenson, pers. comm., 1996).

In some cases comprehensive mitigation may serve to remediate a range of effects. For example, recreational use along the Chilkoot Trail, a national historic site used by stampedeers heading to the Yukon gold fields in the last century, led to the gradual destruction of both ecosystem and heritage components. Comprehensive mitigation and monitoring proved effective in stabilizing the site and eliminating these threats, fostering a landscape perspective that protects both the cultural and natural heritage (Hems, 1996; Hems and Nieuwhof, 1994).

4.3 EVALUATION

The *analysis* of cumulative effects used ecosystem science and professional judgement to identify, as explicitly as possible, the ultimate consequences of a combination of human-induced changes. To understand what those ultimate changes mean, it is necessary to explicitly describe the values context on which the evaluation is based. Existing goals, objectives, targets or umbrella policies will serve as a reference point against which to gauge the overall changes brought about in the environment by the project under review.

When values are explicitly stated, the relevance of the evaluation will be greatly enhanced.

When a proposal is surrounded by controversies and divergent viewpoints, it is important to clearly show how decisions were reached. An explicit statement of values means that the evaluation can be revisited if required.

Values do evolve over time. Changes in scientific information can lead to changes in policy. Thus, it is important to verify the consistency of goals and objectives within the overall policy context in the scoping exercise. Public consultation exercises and management plan updates will also serve to integrate changing values over time. An example of this in Parks policy is the recognition of the importance of ecological and commemorative integrity. This is leading to changes in park management and planning, especially through the development of ecological and commemorative integrity statements.

4.3.1 Using objectives, targets and thresholds

Heritage area goals and objectives are broad orientations established by Parks Canada, often with input from the public, that establish the overall directions management initiatives should take. Goals and objectives specific to each heritage area are provided in park or site management plans, ecological or commemorative integrity statements, and other key documents. Targets are usually specific goals that are resource oriented. For example, the piping plover management plan established a target of 22 nesting pairs for P.E.I. National Park. Thresholds are expressions of limits of acceptable change beyond which a system will be damaged, often irreversibly. It may be impossible to predict the exact point at which

ecosystem collapse will occur. The purpose of thresholds and targets, however, is to develop reasoned guidance for decision making.

Management goals and objectives help in the selection of key components, in setting targets and thresholds, and in assessing significance. Targets and thresholds provide a reference point to evaluate the significance of potential overall changes. In some cases, targets may be expressed as a range of variables rather than a single element. The main selection criteria is that targets and thresholds should be measurable. In some cases, this means they should be quantitative; however, qualitative variables can also be measured and may represent a practical solution in difficult cases. Where possible, established targets and thresholds, such as CCME water quality standards (CCME, 1987), should be used. Trend analysis can also provide valuable insight into how the key component is fairing and whether it is moving towards or away from desired integrity.

Setting limits of any type is a challenging task, and the identification of appropriate thresholds is certainly one of the most demanding aspects of assessing cumulative effects. Problems arise from two sources: firstly, scientific limits and the difficulties inherent to predicting non-linear behavior in complex systems, and secondly, the lack of clear societal goals or objectives that can guide the exercise.

From a scientific perspective, little is known about qualitative or quantitative thresholds, except that those thresholds do exist. For example, Preston and Bedford (1988) describe a

critical loading limit to the ability of wetlands to act as "contaminant sinks". but state that the quantitative limits are difficult to determine. Sly (1994) points out that such thresholds are most apparent once they have been exceeded: this is not helpful for making predictions but does highlight how important monitoring is in learning from our mistakes. Determining the scientific component of thresholds is complicated by what Stankey et al. (1984) called the "it all depends" syndrome: taking into account the various dynamic factors and interrelationships in the environment. While a comprehensive model incorporating all such variables and interrelationships would be desirable (Godschalk and Parker, 1995), it is generally recognized that all models are simplifications affording only partial views of reality, and thus, all models have limitations (Duinker, 1994).

Any determination of ecological thresholds must take into account the natural variations and fluctuations of ecosystems. For example, a vulnerable population may be able to survive under ordinary conditions but lack of food brought on by a drought might lead to its demise. Ziemer (1994) suggests that rare or unusual events are more important in establishing thresholds for wildlife than average conditions. Furthermore, lag times in experiencing impacts can further complicate calculations (Stigliani, 1988). From an ecological perspective, it may be most practical to determine limits imposed by specific resources, focusing on the most vulnerable or "weakest link" in the ecological system.

The absence of clear, well articulated goals constitutes the second difficulty in establishing thresholds. Many goals are jurisdictional and fail to provide the common objectives and

values required for establishing thresholds. In other cases, there may be confusion over the actual values themselves (Sonntag et al., 1987). Recognizing these difficulties, Gosselink and Lee (1989) suggest that development of appropriate goals must be included as part of the planning process.

Given the above considerations, determining thresholds will invariably involve professional judgement. Godschalk and Parker (1995) assert that “the establishment of target levels is an exercise in human value judgement” since there is no “inherent natural rightness” in threshold establishment. Professional judgement may be guided by a cautious overall approach that relies on determining a first approximation of potential thresholds coupled with validation through monitoring (Godschalk and Parker, 1995). Such thresholds must be based on requirements for long-term sustainability of a system (Sly, 1994; CEQ, 1996). Since systems can change over time and predictions are necessarily imperfect, it is important to adhere to the precautionary principle, staying well within system capacity (Sly, 1994).

When thresholds cannot effectively be established, the CEQ (1996) recommends analyzing the trends that result from multiple activities and comparing these with “national, state or community goals” to determine the significance of impacts. Since trends provide an indication of change over time, trend analysis can predict future changes based on extrapolations from past experience. Decisions can then be made on the basis of potential to achieve objectives. For example, the U.S. Department of Commerce (1995) states that: *“Some theorists assert that to promote ecosystem conservation or restoration, decision*

makers should not be asking whether the proposed development would exceed a minimum threshold, but whether it would move the ecosystem closer to or away from the resource goals.” In this sense, thresholds are simply expressed as broad targets rather than levels of use or system capacity.

Once established, thresholds provide valuable insight into the significance of cumulative change. An effect that is approaching an established threshold, or that is perceived to do so, must be considered significant, especially when the rate of change is rapid. Beanlands (1992) has shown that such factors are determinants in promoting action on cumulative effects. Thresholds established at the policy level can then be translated into practical tools for implementation at the project level (Dias and Chinery, 1994). For example, a CEA on oil development projects in Alberta defined regional thresholds for acceptable levels of activity and land disturbance based on key indicator species present and area sensitivity (Eccles et al., 1994).

4.3.2: Evaluating the significance of residual impacts

The significance of residual impacts is of greatest relevance to decision making. Essentially, the potential significance of a proposal, or its various alternatives including the “no-go” option, should be evaluated after the application of technically and economically feasible mitigation measures. Significance can be established most credibly when objectives, targets and thresholds have been identified. For example, it was found that the significance of the

proposed day-use facility expansion on piping plovers was difficult to quantify but possible to qualify because of specific targets established through a joint management plan that provided specific park- and provincial- wide targets for numbers of breeding pairs (Kalff, 1995).

If it is anticipated that thresholds will be approached or exceeded as a result of a proposal, then clearly that proposal becomes unacceptable. In the absence of thresholds, professional judgement will be needed to determine when additional stress acting upon a system results in a significant shift away from ecological or commemorative integrity. Existing and projected future trends will provide guidance and, in some cases, studies from analagous situations or literature reviews can be helpful. Consultation with the public and with experts may also provide insight into the significance of cumulative effects.

4.3.3 Dealing with uncertainties

There are always uncertainties associated with assessing cumulative effects. Ecosystem science may *never* develop to the point where accurate predictions can be made concerning overall change resulting from multiple stressors. Most quantitative assessments have been done in the areas of atmospheric change and water quality due to the availability of sound and tested indicators and a better understanding of cause-effect linkages. Changes to ecosystems, habitats and ecological integrity have been cited as the most difficult areas to deal with. Therefore, uncertainty must be effectively managed and documented.

One of the strategies in dealing with CEA is to avoid being “overawed by complexity” (Cairns, 1986; Erckmann, 1986). This means adopting a common-sense approach to scientific rigour, without losing sight of the primary goals of CEA, making use of best available information and best professional judgement to adopt what Cairns (1986) called a “middle-ground” approach to science. The practitioner must determine when the information available is sufficient, based on the probability of occurrence of cumulative effects as well as the risk of those effects (Bedford and Preston, 1988). Criteria may be developed to help determine this with a reasonable level of confidence: for example, criteria could include whether there is a risk to the life, health or vigor of a VEC, and whether the probable magnitude of that effect is understood (Hegmann and Yarranton, 1995). Practitioners must make the most of available information in order to help decision makers in the face of scientific uncertainty (Hirsch, 1988).

Effective analysis means that complexities must be limited and issues simplified to focus on major cause-and-effect linkages (Dayton, 1986; Hegmann and Yarranton, 1995). In the words of Clark (1986): *“One of the most useful roles for science in environmental impact assessment is therefore to reduce as many apparently cumulative problems as possible to simple cases of single cause and single effect.”* This simplification would be aided by effective scoping to focus on broader patterns rather than details and by effective selection of VECs and indicators. At the same time, excessive abstraction must be avoided (Baskerville, 1986). Thus, realistic assessment strategies should be developed to determine which pathways offer the best opportunities for study and prediction given constraints

imposed by time, ecosystem science and technical limitations (Beanlands and Duinker, 1983). Similarly, assessments should clarify which predictions can and should be attempted (O'Riordan, 1986).

A common-sense approach to science would also involve determining where quantification is possible and desirable, balancing the needs of the assessment with the realities of science. Lawrence (1993) points out that quantification has its disadvantages in that it fails to systematically consider intangibles, cannot capture all the complexities of ecosystems, may misrepresent values and is not free from bias. Thus, in some cases cumulative effects *cannot* be represented quantitatively. He argues that the preferred solution often lies in the middle ground between quantification and qualification. Semi-quantitative methods of hypothesis generation have been developed by Duval and Vonk (1994) who stress that one of the important aspects is the need to document all assumptions, calculations and conclusions. Several scenarios may be postulated when uncertainty is high, and then tested to verify their probable levels of accuracy (Hegmann, 1995; CEQ, 1996).

All assumptions, judgements and limitations must be clearly documented, the precision and accuracy of information required or available should be clarified, and the level of uncertainty should be quantified where possible (Environmental Resources Limited, 1985; Hirsch, 1988). Documentation allows predictions and recommendations to be revisited should any of the assumptions be eventually proven false. Information on statistical probabilities is relevant to determine overall uncertainty; however, qualitative assumptions are also

important. The assessment should note when assumptions are based on highly abstract studies, or when data are extrapolated from other geographical areas. Assumptions regarding future growth conditions, visitor behavior or environmental conditions should all be made explicit. Thorough follow-up is required to verify whether predictions were accurate and whether unexpected impacts occurred. In such situations, project implementation should be flexible, based on adaptive management techniques (CEQ, 1996), and monitoring and feedback become critical.

Uncertainty can also be managed through application of the precautionary principle, which has been defined as the use of caution in making changes to environmental systems when scientific understanding is incomplete or when an area is highly susceptible to damage. The founding premises are that nature is valuable in its own right; that governments must be willing to take action even in the absence of formal, scientific proof; that the burden of proof lies with those proposing a change; that all decisions have a cost, and that caution may signify forgoing certain opportunities; and that current actions will affect the future (Page et al., 1996a).

The precautionary principle raises the question of burden of proof, which is highly relevant for assessing cumulative effects. How certain must predictions be? Must the environmental assessment provide irrefutable proof that a proposal will lead to unacceptable effects, or is it up to the proponent to prove that the proposal will not have effects? Based on the interpretation of the precautionary principle, the burden of proof must rest with the

proponent: the environmental assessment can only be expected to document uncertainty. It then becomes the decision maker's responsibility to take uncertainty into account when making decisions, and to apply the precautionary principle.

A final strategy for dealing with uncertainty involves monitoring and follow-up. Simply put, the greater the uncertainty, the more important it is to follow up on actual changes. Predictions or trends involving a high level of uncertainty should be carefully monitored over time to validate the conclusions and the proposed mitigation. Monitoring allows unexpected negative impacts to be corrected should they occur. Monitoring will also allow us to learn from our experiences, so that future assessments can be improved. Issues may be investigated under specific programmes, or incorporated into ongoing integrated monitoring.

4.4 FOLLOW-UP, FEEDBACK AND DOCUMENTATION

The purpose of an environmental assessment is to identify the potential impacts of a proposal, and to provide the responsible authority with enough information regarding residual and unavoidable impacts to make an informed decision regarding the proposal. The potential implications of cumulative effects are an important part of these considerations.

Documentation is important for several reasons: ensuring information is made available to interested parties, recording the reasoning that may have led to a decision and providing a basis for learning from our experiences. Conclusions of the assessment and any related

recommendations presented in the screening report must include conclusions and recommendations relating to cumulative effects.

4.4.1 Surveillance and follow-up requirements

Monitoring is critical to help alleviate the high uncertainty associated with assessing cumulative effects (Contant and Wiggins, 1991; CEQ, 1996). Proposal-specific monitoring will be required in CEA, as it is in conventional EA, to verify the accuracy of predictions, the effectiveness of mitigation, and to ascertain whether unanticipated impacts are occurring. Surveillance monitoring, during proposal implementation, may be required to ensure that mitigation measures have been implemented and that recommendations have been respected. After completion of the proposal, follow-up will allow us to see whether predictions are correct and whether any unanticipated effects are occurring.

Such monitoring programs should include the following components (CEQ, 1996):

- measurable indicators of change;
- time frames;
- spatial and temporal scales;
- means of assessing causality;
- means of measuring mitigation effectiveness; and
- provisions for adaptive management.

Cumulative effects assessment involves understanding the context in which the proposal will take place. This means that traditional approaches to monitoring should also be expanded to cover broader temporal and spatial scales, and to consider the potential effects of a proposal within the context of other activities and proposals. Sonntag et al. (1987) recommended integrated monitoring as a means of best achieving this purpose: “*Design and implement areawide and long-term monitoring programs to support the comprehensive assessment framework contained within CEA.*” Such integrated monitoring programmes may require a co-operative approach where several agencies are involved and single proponents cannot be responsible for the range of potential stressors acting upon a system (Davies, 1992).

Effective monitoring for CEA, therefore, involves a combination of traditional stressor-specific monitoring and integrated monitoring aimed at assessing the overall integrity of the system. A two-pronged approach to monitoring, including both integrated and threat-specific monitoring, was put forth by Woodley (1993a). He recommends the implementation of threat-specific monitoring to follow the effects of known stressors, while ecosystem-integrity (or integrated) monitoring is used to detect suspected or unsuspected effects. Thus, integrated monitoring is based on a suite of indicators of system integrity (Woodley, 1993a)

Munn (1994) recommended the inclusion of five elements in a long-term monitoring strategy:

1. include testable hypotheses (what-if scenarios):
2. use an ecosystem approach and indicators of ecosystem integrity:
3. select a range of VECs reflecting analytical and stakeholder concerns:
4. make the greatest possible use of existing monitoring programmes or systems; and
5. monitor trends in underlying socio-economic and cultural causes of environmental stress, as well as in the biophysical environment.

It is critical to combine monitoring with an effective feedback system, to ensure that the results can be incorporated into future environmental assessments and decision making. An adaptive approach to management can ensure that such feedback provides better protection of the environment (CEQ, 1996).

4.4.2 Feedback Requirements

Follow-up requirements may include factors that involve not only the proposal being assessed, but other sources of stress acting upon the system. Stressors, pathways and the response of the environment may all change over time. Some effects may be felt after significant time and space lags. Ideally, an integrated monitoring programme for each heritage area would provide information on an ongoing basis on both the accuracy of predictions in environmental assessments and the actual response of the environment, with a special focus on areas of uncertainty. It is important to integrate the results of the integrated monitoring programme into the ongoing information management process.

Documentation of the cumulative effects of proposals extends beyond the preparation of a screening report. Because the cumulative effects themselves relate to the land base and not only to the proposal at hand, it may be necessary to ensure that the results of the analysis and evaluation are incorporated into products of the *Natural Resources Management Process* or the cultural heritage equivalents. For example, new information should be incorporated into park data bases and resource syntheses and analyses. Some recommendations may touch upon potential policy changes and should be incorporated into management plan reviews. New information may have been generated on trends of key environmental components, cause-effect linkages or critical thresholds: this must all be incorporated into relevant documents such as ecosystem management plans or even integrity statements. The information must also be made available to assist in future environmental assessments of related projects or activities.

It is imperative that management be made aware of any key components that may be approaching critical thresholds or limits, or any targets that are clearly being missed because of human activities within or around the heritage area. Such information, which may be obtained in the course of an environmental assessment, must be highlighted; corrective measures should then be implemented especially at the management plan level.

Effective feedback will be instrumental in helping to avoid duplication relating to cumulative effects assessment. Any information on the overall context of cumulative effects, including past, present and future projects or activities leading to stress on the system, pathways of

change and overall consequences, will be relevant to most assessments occurring within a given heritage area. Individual parks or sites may wish to maintain information relating to cumulative effects in a way that favors ongoing updating, for example, by recording information on a GIS system. Such living documents would be used repeatedly for both project- and plan-level assessments within the heritage area.

4.4.3 Documentation

To be effective, cumulative effects assessments must be well documented, and the results should be clearly communicated to decision makers and stakeholders (Davies, 1992).

The importance of documentation was emphasized by Duval and Vonk (1994) who incorporated the production of an “audit trail” in their approach to CEA. Effective documentation means that the analysis or evaluation can be revisited should environmental or project conditions change. A well-documented CEA can also provide key information for future assessments.

Effective communication of results is also critical, and it was often lacking in the earlier generations of environmental assessments where long descriptive documents were produced (Ginger and Mohai, 1993). Hegmann (1994) noted the importance of “succinct and focused” EAs to effectively communicate findings. Because cumulative effects assessment incorporates considerations relating to a context of activities rather than a single proposal,

and including results of multiple small decisions, it is important that the implications of such decisions be made as clear as possible.

Zeimer (1994) emphasizes the importance of “telling the story”. He outlines an example of a multi-million dollar freshwater habitat rehabilitation project in California to protect anadromous fish that was jeopardized by drainage activities downstream to save crops worth several thousands of dollars. Such examples are no doubt numerous and illustrate the need to communicate findings and results of assessments and studies.

Recommendations should be relevant to decision makers: *“Ideas can have strong intuitive appeal, yet not affect decision-making because they lack any explicit operational formulation”* (Preston and Besford, 1988). Irwin and Rodes (1992) recommend the use of graphics to display scales of action and movement of pollutants: *“One reason for the eventual success of the Montreal negotiations in getting agreement to protect the stratospheric ozone layer was the skill of scientists, diplomats, and journalists in clearly explaining the problem, particularly the graphic presentation of the ‘ozone hole’.”*

The following should be included in the documentation:

- ❖ the process used to consider alternatives or assess trade offs between various types of cumulative effects;
- ❖ methods used;

- ❖ the description of the environment: to include any key or critical features of the overall environment including any trends causing concern;
- ❖ the identification of potential impacts: to include the contributions of the proposal to existing stressors especially regarding any critical limits or thresholds, as well as sources and levels of uncertainty;
- ❖ any options or alternatives considered;
- ❖ mitigation proposed, including rehabilitation proposals or corrective measures to reduce other sources of stress;
- ❖ the significance of residual cumulative effects;
- ❖ monitoring requirements, including a detailed monitoring plan where required;
- ❖ future studies that may be required.

4.5 SUMMARY OF STEPS

The step-by-step guidance outlined above can be summarized as a detailed approach for the convenience of practitioners (see Table 5).

Table 5 Detailed approach to assess cumulative effects: a summary of the steps involved	
1. SCOPING	
1.1	What is the policy context of the given area? Is the proposal consistent with current policy and plans? Ensure consistency with the decision-making level and established plans and policies.
1.2	What are the main issues and concerns stemming from the proposal under review?
1.3	What are the key environmental components involved?
1.4	What is an appropriate scale of assessment? Include spatial and temporal boundaries.
2. ANALYSIS	
2.1	What are the sources of stress acting upon the key components affected by the proposal?
2.2	What are the major pathways involved?
2.3	What are the responses and overall trends of the key components ?
2.4	What is the relative contribution of the proposal to this overall situation? Consider any proposed alternatives to the proposal. How do the potential impacts that may arise from the proposal affect overall context and trends?
2.5	What mitigation methods can be applied to eliminate or reduce the overall cumulative effects?
3. EVALUATION	
3.1	What specific goals and management objectives are relevant to the issues at hand? What are the targets or carrying capacity established for these components?
3.2	What is the significance of residual impacts in terms of overall integrity ? Will the changes brought about by the proposal bring the heritage area closer to its overall objectives? Will ecological or commemorative integrity be enhanced or diminished?
3.3	What uncertainties and risks are involved?
4. FOLLOW-UP, FEEDBACK AND DOCUMENTATION	
4.1	Identify surveillance and follow-up requirements.
4.2	Identify feedback requirements (to the management plan, cumulative effects background studies or other appropriate feedback points).
4.3	Document relevant information (include in the screening form or report: environmental setting, nature and extent of cumulative effects, mitigation, public concern, monitoring requirements, etc.).

4.6 CHAPTER CONCLUSIONS AND NEXT STEPS

Chapter 4 has provided overall step-by-step guidelines for assessing cumulative effects based on the principles and conceptual framework outlined earlier. The steps outlined are iterative, flexible and adaptable, and are based on the approach used in environmental assessment: scoping, analysis, evaluation, documentation, feedback, and follow-up.

The next chapter presents the results of three test cases used to evaluate the approach.

CHAPTER 5

TESTING THE APPROACH

5.1 TESTING THE APPROACH IN LA MAURICIE NATIONAL PARK

5.1.1 Rationale

The principle of tiering is considered fundamental to the CEA framework, and to best assess the applicability of the approach to the different decision-making levels it was deemed essential to undertake tests at both project and strategic levels. La Mauricie National Park provided an excellent context for testing the approach, since it is readily accessible, and background information on resources is currently available. A proposed development of a long-distance hiking trail in the park provided an opportunity to apply the CEA approach at the screening level for a project typical of those being undertaken within Parks Canada. The approach could also be tested at a strategic level through a preliminary scoping of the Park Management Plan, scheduled for review in 1997-98. Together, the two test cases would examine the links between project- and plan-level assessments.

The following section describes the park, focusing on key issues such as the biophysical and regional setting, human actions that have changed the park environment over time, facilities available, and general issues of concern. The results of the test cases are then presented in Sections 2 and 3.

5.1.2 La Mauricie National Park

The purpose of La Mauricie National Park is *“to preserve, for all time, a natural area of national interest that is representative of the St. Lawrence Lowlands - Great Lakes natural region. At the same time it aims to protect this natural heritage area for the benefit, education and enjoyment of present and future generations of Canadians”* (Canadian Parks Service, 1991).

Created in 1970, the park is a relatively recent addition to the Canadian national park system. It is located approximately 70 km north of Trois-Rivières, in the Quebec Laurentians, halfway between the two most populous metropolitan regions of the province, Montreal and Quebec City. The park itself is fairly small, totalling only 544 km², and is bordered by the Matawin and Saint-Maurice rivers, two provincial wildlife reserves, agricultural lands, and several small villages.

The topography of the park, fashioned by the last ice age, consists of low rounded hills, steep cliffs and valleys containing an extensive system of lakes, streams, and waterfalls (Canadian Parks Service, 1991). The park lies in a transition zone between the Canadian Shield and the St. Lawrence Lowlands, and its extensive forest cover includes components of the deciduous maple-birch forests to the south and the coniferous, boreal forests to the north (Pelletier, 1993). As a result, the park fauna and flora are rich and varied. (Canadian Parks Service,

1991).

The park territory has been extensively modified since first used by Europeans for trapping at the turn of the seventeenth century (Canadian Parks Service, 1991). Logging practices in the mid-nineteenth century greatly reduced the stands of white pine that were once characteristic of the region (Bouin, 1993). The development of the pulp and paper industry in the early twentieth century exacerbated logging in over half of the park forests, completely altering vegetation composition and distribution (Bouin, 1993). Wood was floated on lakes and rivers to pulp mills, and dams were built along the waterways to facilitate log driving and to provide energy to sawmills. In so doing, the aquatic regimes were modified, wetlands submerged, fish habitat destroyed, and water quality affected by the accumulation of sawmill and log wastes (Canadian Parks Service, 1991; Bouin, 1993).

Private hunting and fishing clubs were established about 1880; in exchange for managing the territory, they negotiated exclusive rights to the land. As a result, non-native fish species were introduced into many lakes and certain native fishes removed (Bouin, 1993). Over 16 private clubs occupied the park by the time it was established; however, all hunting and logging operations have since ceased within park boundaries. Sport fishing is permitted, although the effects of this type of resource harvesting are currently being investigated. Hunting, fishing and logging continue in areas adjacent to the park, including the wilderness reserves (Routhier, 1993; Therrien, 1993).

The park is vulnerable to large-scale trends such as climate change and atmospheric pollution: over 17% of lakes are currently acidified and another 29% are in the process of acidification (Parcs Canada, 1996). Forest health is also thought to be affected. On a regional level, harvesting of renewable resources adjacent to the park has isolated park ecosystems. Aquatic communities have been significantly altered by the introduction of non-native species, erosion, and the alteration of natural processes such as nutrient cycling and hydrological regimes.

Ecological processes have been considerably modified by past activities. Forest structure and aquatic systems have been transformed, with a general loss of biodiversity. The loss of terrestrial mammals is estimated at approximately 14% over the last 150 years, while 22 non-native species of fish have been introduced into the system, and 5% of the flora is considered non-indigenous.

5.1.3 Visitor use and facilities

A 63 km scenic parkway, closed in winter, provides the main access into the park. The drive arcs in a semicircle through the southern half of the park, connecting five high-use areas consisting mainly of camping and picnic sites, as well as various lookouts and hiking trails. A visitor centre is located at each end of the parkway, one at Saint-Jean-des-Piles and the other at Saint Mathieu. Exhibits and interpretive information are provided at the visitor

centres, at the main campground, and at trailheads and lookouts along the parkway.

The park attracts over 373,000 visitors yearly¹, mostly during the summer season. The most popular recreational activities are water-based, and include canoeing, canoe-camping, swimming and fishing; picnicking and day hikes are also widely enjoyed. Mountain biking is permitted along designated trails. In autumn, many visitors drive along the scenic parkway to admire the fall colours. The park also attracts approximately 30,000 cross-country skiers and snowshoers in winter. The majority of all visitors live within the region (Canadian Parks Service, 1991). Most overnight visitors stay at one of the four campgrounds within the park, which include a 488-site main campground, a 29-site walk-in campground, a 100-site group campground and 53 wilderness campsites. The popularity of camping is increasing and campgrounds are often filled to capacity. Two lodges are also available, accommodating up to 45 people daily.

Traffic congestion and crowding are common occurrences during the summer; the most popular activities are concentrated in specific locations, and sites are closed regularly on weekends when parking lots are filled (Canadian Parks Service, 1991). Even in backcountry locations, the high levels of use have led to a decline in the quality of both the visitor experience and the integrity of the natural resources (Bouin, 1993). Indicators of the loss of ecological integrity include diminishing reproductive success for vulnerable species such as

¹ based on 1988 figures

the common loon, and increasing presence of invasive, non-native species (Parcs Canada, 1996).

5.2 FIRST TEST CASE: PROPOSED LONG-DISTANCE HIKING TRAIL IN LA MAURICIE NATIONAL PARK

5.2.1 Project proposal: the long-distance hiking trail

The development of a long-distance hiking trail in the northern backcountry sector of La Mauricie National Park had been proposed in the initial management plan for the park, and retained in the current plan as the only outstanding facility yet to be developed (Canadian Parks Service, 1991). The purpose of the trail is to provide a backcountry experience to park visitors who wish to enjoy a closer contact with nature. Contacts with other parks and with the National Trail Association indicate that a clientele exists for this type of activity (Les Consultants Jacques Bérubé inc., 1996a).

The proposed trail would form a semicircle through the northern sector of the park, covering approximately 75 km. Existing parking lots would serve as arrival and departure points; at each end of the trail, a 15 km “day loop” would allow users without adequate preparation to return without retracing their steps. Since use is anticipated to be higher along these “day loops”, they will be developed to frontcountry standards. The rest of the trail will be lightly

developed, with a hiking area 0.5 m wide by 2.5 m high, and a cleared area 1.2 m wide by 2.5 m high (Les Consultants Jacques Bérubé inc., 1996a).

The proposed route would take approximately 4 or 5 days to complete. Branch trails will connect the main trail to observation points and to approximately 10 primitive campsites. Campsites will consist of four wooden tent pads, a pit privy, a system for protecting food from bears, and a rudimentary shelter for preparing food.

Preliminary field inspections started in June 1995, and project planning was initiated in early 1996. Route selection and field operations were scheduled to occur from July 1996 to October 1997, while the opening of the trail is planned for September 1997.

A co-operative approach to planning was adopted with input from various park sectors and early incorporation of environmental considerations. The preliminary route was selected on the basis of six criteria:

- avoidance of areas designated as conservation priorities 1 and II;
- avoidance of steep slopes (over 30%);
- avoidance of areas with poor or incomplete drainage;
- inclusion of characteristic park elements and interesting scenery;
- selection of resistant areas for the construction of turnaround loops;

- distancing campsites from the main trail and from waterway banks and shorelines.

Modifications to the proposed route were incorporated as a result of input and site visits by wardens responsible for natural resources within the park. Recommendations concerning both the construction and operations of the trail were proposed and incorporated into the project proposal. For example, manual construction, the transportation of material by helicopter, the avoidance of on-site storage of petroleum products, and the minimization of tree cutting and waste production all contributed to reducing construction-phase impacts (Les Consultants Jacques Bérubé inc., 1996a).

Experience in other parks suggests that the operation of long-distance hiking trails must be carefully controlled to avoid overuse, crowding, and deterioration of trail conditions. As a result, an overall quota of forty users per day and campsite quotas of four tents per site were established. Levels of use will be controlled through a mandatory registration system, and information on park regulations and safety measures will be provided to all users (Les Consultants Jacques Bérubé inc., 1996a).

5.2.2 Summary of initial screening

When the proposed hiking trail project was initiated in the spring of 1996, an environmental assessment was undertaken in accordance with the requirements of the *Canadian*

Environmental Assessment Act (Les Consultants Jacques Bérubé inc., 1996a). The assessment identified elements of the environment that were likely to be affected by activities resulting from project construction, operation and maintenance.

The EA identified the potential for very minor local impacts on soil, water and stream crossing, as a result of the construction phases of the project. Only very minor impacts were anticipated on wildlife and vegetation as a result of trail use: the assessment noted that careful routing of the trail avoided all rare or fragile species, known archaeological and cultural resources, and two lakes designated for special conservation. Food protection systems and user education would minimize risks to hiker safety. Minor mitigation measures and a follow-up program were proposed for residual impacts. The EA concluded that the trail would not generate significant impacts given the environmental considerations integrated into the planning process (Les Consultants Jacques Bérubé inc., 1996a).

However, the assessment of cumulative effects was cursory. The EA noted that current backcountry activities such as canoe-camping would not intersect with the proposed hiking activities, and the proposed trail would not exacerbate existing problems such as acid rain or hunting along the edge of the park. Habitat fragmentation was only considered at a very small scale (Les Consultants Jacques Bérubé inc., 1996a). It was felt, therefore, that the assessment could be improved by a more detailed analysis of potential cumulative effects.

5.2.3 General approach and scoping cumulative effects

An initial workshop was held as a starting point for the assessment of cumulative effects. Participants included park wardens, a member of the project planning team, representatives from Parks Canada headquarters and the Quebec regional office, as well as a consultant undertaking the assessment. The purposes of the workshop were to scope key components and issues, determine appropriate scales, identify known past, present or future activities and stressors, and identify some of the cause-effect linkages requiring more in-depth analysis. Additional analysis and research were then undertaken by the consultant, and a second workshop held to validate the findings of the assessment, the evaluation of significance and the mitigation proposals. Results of the assessment were documented in a separate report (Les Consultants Jacques Bérubé inc., 1996b) but were also incorporated into the initial screening to complete the project EA.

The scoping process involved an analysis of the policy context for the project, the identification of main issues of concern, and the determination of appropriate spatial and temporal boundaries. The policy context for the project was clear; the park management plan is the document that provides direction for balancing the primary mandate of protecting the ecological integrity of the park with the promotion of public use, enjoyment and understanding. The long-distance hiking trail was proposed in both the current and previous management plans, and the location was consistent with park zoning. The project being

promoted was felt to be inherently supportive of park goals, since it involves a low-intensity wilderness activity requiring a minimum level of development (Les Consultant Jacques Bérubé inc., 1996b).

The workshop forum proved very effective for identifying issues of concern, especially with the adoption of a broader regional perspective. It became obvious that human pressures are mounting in all areas adjacent to the park. Hunting, fishing, trapping, logging, recreational activities, the use of snowmobiles and all-terrain vehicles, intensive farming and maple sugar production all occur in the surrounding areas. High levels of use also occur within the park, especially along the scenic parkway and canoe-camping routes. Thus, in the entire region, only two small sectors in the northeastern and northwestern portions of the park remain relatively inaccessible.

In light of the regional context of development and use, the overall consequences of opening up the only remaining relatively untouched territory to human use was immediately questioned, especially with regards to the effects on wide-ranging top predators such as wolves, as well as on vulnerable species such as loons. In turn, this concern guided the selection of scales, since spatial boundaries obviously needed to be broad enough to include all territory used by wide-ranging species, and were thus extended beyond park boundaries to include the regional ecosystem and adjacent wildlife reserves. A time frame of 25 years was selected, chiefly because of data availability since the creation of the park. It was felt

that any reasonably foreseeable future activities must also be included in the analysis.

5.2.4 Identifying contributing stressors

The second step of the draft approach involved identifying the contribution of the project to overall stressors acting upon the ecosystem. All stressors acting upon relevant key components of the environment were identified, and potential changes caused by the project were examined.

This stage of the assessment focused primarily on the effects of intrusion into the backcountry of the park. While the narrow width of the trail would not result in a “physical fragmentation”, since ground cover would be uninterrupted, the question centred on whether a “technical fragmentation” would affect species sensitive to humans, especially species with large territories or those that frequent only a small number of very specific sites (Les Consultants Jacques Bérubé inc., 1996b). Such species could include timber wolf, moose, black bear, lynx, fish, marten, common loon and large birds of prey.

Following an initial analysis of these components, three features were retained for more detailed consideration:

- the timber wolf, which represented a large-ranging species and was considered

especially vulnerable to human intrusion:

- the black bear was retained on the basis of potential increases in bear-visitor conflicts;
- the common loon was retained since nesting pairs are especially sensitive to human-induced disturbance.

The analysis then focused on identifying existing sources of stress that affect the three species retained. Close to fifty such stressors were identified and grouped into categories to allow an analysis of the current context for each key component retained.

The status of the wolf population within the park is considered precarious. Two small wolf packs, varying in size from three to six individuals, frequent the park; however, the presence of one of the packs is sporadic (Masse, 1993). The park itself constitutes only a portion of the territory required by the wolves, which also frequent adjacent lands. While the wolves avoid the southern portion of the park where human presence is greater, disturbances can occur even in the backcountry, since a portion of the area is accessible by canoe-campers. Furthermore, since timber-floating along the Saint Maurice River was abolished, an increase in truck traffic to the east of the park generates high and fairly constant levels of noise in some areas. On a regional basis, the wolf population is in decline as habitat is lost to urbanization and agriculture. Intensive hunting and trapping programmes, and competition with coyotes, have further reduced the population.

In terms of the wolf population, the main question for the assessment was whether the levels of use intended for the long-distance hiking trail would constitute an unacceptable intrusion on a population already under a considerable level of stress throughout its habitat.

The second key component examined was black bears. Unlike the wolf, black bears are relatively abundant within the park, and the population, estimated at between 100 and 125 animals, is relatively stable. Bears use the territory adjacent to the park, especially in the summer months when they forage for food (Les Consultants Jacques Bérubé inc., 1996b). The main question in terms of cumulative effects was whether a backcountry trail would significantly increase the potential for bear-hiker conflicts.

The third key component selected was the common loon. Monitoring programs have indicated that the nesting success of the park loon population, estimated to range between 13 and 20 breeding pairs, is in decline (Masse, 1996). Stressors include human disturbance during the incubation period; loons have abandoned lakes used by a large number of canoeists. Loons are also adversely affected by lead weights used for fishing, and by acidification of lakes (Masse, 1996). Finally, loss of migratory habitat is also a factor in the overall loon decline. The analysis for loons therefore focused on whether the project would further contribute to the existing deterioration of the quality of habitat for this vulnerable species.

5.2.5 Analysis of cumulative effects

The next step of the approach involved the analysis of overall effects in terms of existing trends and management objectives or known thresholds. This step includes the assessment of alternatives and the development of mitigation measures.

The long-term survival of all three key components selected for the assessment is critical to support ecological integrity. However, no studies have been undertaken to establish minimum population levels for these species. Park objectives include maintaining bear populations at their current levels, while a specific objective of maintaining breeding pairs of loon on at least 25 park lakes has been developed (Masse, 1996).

Resolving the issue of level of disturbance caused by the trail to the wolf population was not an easy task. Two possible scenarios were developed. In the first, the very presence of the trail would result in complete avoidance of the entire sector by wolves; in the second scenario, wolves would avoid areas surrounding the trail when hikers were present. Based on professional experience, it was determined that the most likely response would be a slight altering of wolf territory during the summer and fall (Les Consultants Jacques Bérubé inc., 1996b). The extent of this effect was seen as proportional to the number of hikers using the trail. The actual extent of impacts would require validation by monitoring the wolf population. Therefore, the very strict application of user quotas was seen as extremely

important, as was the closure of the trail over winter. Additional suggested mitigation measures included the development of co-operative agreements with adjacent land managers to reduce or eliminate trapping pressure.

The potential increase in bear-hiker conflicts created by the trail was seen as minimal, given the existing mitigation measures proposed for food storage and user education. Ongoing monitoring and recording of all incidents was required.

Some modifications to the trail route were recommended in the western sector to avoid three lakes considered important for loon nesting. Four campsites were also relocated to avoid nesting areas. Further mitigation measures involved the provision of relevant interpretive information to hikers. An annual monitoring programme was also recommended. In the event of unexpected impacts on the loon population, additional mitigation, such as the temporary closing of specific sites during the breeding season, and reduction of activities such as canoe-camping or fishing in other sectors, were recommended (Les Consultants Jacques Bérubé inc., 1996b).

5.2.6 Evaluation and recommendations

The final steps of the approach involved evaluating the significance of the changes brought about by the proposed project within the context of existing stressors, and recommending

follow-up and feedback requirements in light of this evaluation.

Recommendations included the implementation of all mitigation and monitoring requirements identified above. In addition, the question of future growth potential was addressed. The assessment expressed concern that, once the trail was developed, more intensive use such as increased hiker quotas or initiation of winter skiing, may be brought about by gradual increments. In light of the cumulative effects discussed, limits on the number of hikers and on seasonal use of the trail were considered particularly important. The assessment states: *"Do not authorize the trail to be used in any manner which differs from that proposed in the current project..., unless the necessary monitoring or studies have first been carried out showing the absence of significant additional effects on the Park's key species."* (translated from original, Les Consultants Jacques Bérubé inc., 1996b).

The broadening of existing monitoring programmes to measure direct impacts such as erosion, introduction of undesirable species, and development of unofficial trails was also recommended.

Other recommendations include obtaining data on other wide-ranging species such as lynx and fishers, in order to monitor the effects of the trail on such species and to identify key habitat required for their long-term survival. The assessment also found that the Park Management Plan provided insufficient levels of information regarding acceptable

backcountry activities and optimal levels of use. It recommended the development of specific carrying capacities for both land-based and aquatic uses of backcountry areas, and a more effective use of zoning to prevent gradual increases in backcountry use (Les Consultants Jacques Bérubé inc., 1996b).

The assessment concluded that the proposed trail brought to the forefront the question of appropriate levels of use in previously inaccessible backcountry:

“While the relative impact on the black bear and the common loon can be minimized through mitigation, the use of the trail could prove to be enough of a stressor to contribute to the fragmentation of the area frequented by the timber wolf, a key species that is sensitive to the presence of humans. Although this potential impact is not enough to call into question the validity of the trail project, there is a need to clarify, as part of the environmental monitoring process, the effects of the trail's use on the presence of the wolf in this region of the Park.”

“On the whole, it seems unlikely that the proposed trail will compromise native diversity in the Park nor, for that matter, the area's ecological integrity. It is recommended, however, that use of the trail be limited to the levels proposed in the current project (La Mauricie National Park, 1995) and that any associated development in and around the trail or in the same sector be banned over the short and medium term. It is also recommended that components which will eventually make it possible to clarify the actual effects on the timber wolf, black bear and common loon and to minimize the risks of introducing undesirable plant species be added to the environmental monitoring provided for in the project. Proper environmental monitoring will make it possible to intervene effectively, where required, to maintain the eventual effects of the project to their lowest possible level.” (translated from original, Les Consultants Jacques Bérubé inc., 1996b).

5.2.7 Evaluating the test case

The test case was considered on the basis of the ten evaluation criteria identified in Chapter 1:

- *Clarity of purpose:* The approach provided clear direction; the assessment was undertaken by a consultant with the participation of Parks Canada staff but could equally have been implemented by park staff. The use of a workshop proved particularly effective in scoping issues and concerns, and provided direction for the analysis that followed.
- *Incorporation of broad perspective:* The approach focused attention on the bigger picture, and specifically on the key issue of appropriate levels of use in backcountry ecosystems, and effects on key indicator species, given the stressors affecting these species outside the park. These issues were not identified in the initial environmental assessment, which was undertaken following a more traditional approach.
- *Scope of application:* The test case demonstrated that the approach can be applied successfully to the screenings of projects typical of those undertaken within Parks Canada.
- *Stakeholder involvement:* The approach brought together stakeholders from the Park warden services, the project manager, the Quebec regional office, and the national office of Parks Canada, as well as the consultant who undertook the assessment, through the initial workshop and in subsequent consultations. Other stakeholders were consulted in the course of the initial environmental assessment.
- *Interjurisdictional:* The approach provided for the broader ecosystem perspective as defined in the scoping exercise. It is precisely this broadening of spatial boundaries beyond the park borders that allowed for the identification of broader

issues of concern.

- *Monitoring and feedback:* The test case identified the need for ongoing monitoring of the three indicator species retained for analysis and mitigation. The approach uses the current management process as a mechanism for feedback based on the results of the monitoring programme.
- *Timely input into decision making:* In this case the environmental assessment of the proposed project had been completed prior to initiation of the test case. These circumstances provided an opportunity to compare the results of the CEA with the results of a “traditional” environmental assessment. Normally, however, the cumulative effects assessment would be undertaken as an integral part of an environmental assessment. In either case, the approach is applicable early in the planning stages of the project. The analysis was completed in a timely fashion and the results were incorporated into project decision making.
- *Flexibility and adaptability:* The cumulative effects assessment was adapted to the circumstances at hand; not every step described in the approach was used and early scoping focused the analysis on specific areas of concern.
- *Cost-effectiveness:* The approach relied heavily on existing information and existing processes and made use of in-house expertise where applicable. Thus, it was very cost-effective.
- *Insight for long-term direction:* The approach provided direction for the assessment at hand but also raised long-term issues, such as appropriate levels of use for

backcountry areas, to be dealt with at the management planning level.

In conclusion, the approach was effective in meeting the established criteria and providing guidance for the assessment of cumulative effects. Through application of the framework, previously overlooked issues were raised in a typical project screening and these issues were resolved sufficiently to allow a more informed decision to take place at the project level while flagging broader issues to be resolved through an appropriate forum.

5.3 TESTING THE APPROACH ON A PARK MANAGEMENT PLAN

5.3.1 Initial considerations and approach

Many issues raised in assessing the context of the long-distance hiking trail were management planning issues; in fact, the fundamental question of identifying appropriate levels of use in the backcountry without compromising ecological integrity is best resolved at the management planning level. Thus, results of the trail assessment provided input into a second test case, the assessment of the La Mauricie National Park Management Plan.

The test case cannot be viewed as a complete assessment of a management plan. First, such an assessment would focus not only on the existing plan but also on the proposed revisions which are not yet available. Ideally, the assessment would be fully integrated into the

revision process, so that the implications of the conceptual-level trade-offs would be clear at every step, and informed decisions would be taken at every phase of the planning process. This test case, therefore, can only lay the groundwork for the eventual assessment of the revised management plan. The intent is to scope the main cumulative effects associated with the current plan. Here a distinction must be made between assessing the overall consequences of a plan, and assessing the collective consequences of proposals contained within that plan. If the purpose of the plan is to provide guidance to assist in balancing the preservation of ecological integrity with goals of public use and enjoyment, then the absence of sufficient guidelines will lead to potentially high levels of impact even if all proposals within the plan are environmentally sound. In essence, this is the challenge of assessing the cumulative effects of plans.

The approach adopted for the assessment of the plan was similar to that of the trail assessment. The initial scoping workshop identified key components and provided a range of issues that were relevant to the planning level. The preliminary assessment was undertaken in-house, and a follow-up meeting specific to the management plan was held to discuss and validate the preliminary findings.

5.3.2 The nature of the management plan

The purpose of a park management plan is to provide “*strategic direction for the*

management and operation of a park or historic site and [to] provide a framework for subsequent business and work planning." (Department of Canadian Heritage, 1994b). Management planning must also provide "*measurable benchmarks of ecological and commemorative integrity*" (Department of Canadian Heritage, 1994 b).

These guidelines have been interpreted differently throughout the country and, as a result, national park management plans exhibit some fundamental differences. In some cases management plans provide detailed strategies listing future projects and activities planned within the park. In other cases, the management plans remain fairly general, providing only very broad statements and directions. The La Mauricie management plan is an example of the latter.

The first management plan for La Mauricie National Park was approved in 1979, shortly after the creation of the park. It identified the facilities and services deemed necessary for the development of the park and for its use and enjoyment by visitors. Most of the development objectives identified have since been attained. As required by Parks Canada policy, the original management plan was revised, resulting in the current (1991) version. In turn, this plan is scheduled for review in 1997. The 1988 amendments to the *National Parks Act* stipulate that all revised management plans must be tabled before Parliament, thereby triggering an EA under the *Environmental Assessment Process for Policy and Program Proposals*.

The current management plan consists of a brief description of the park and its resources, and an overview of the development of the park since its creation. Major problems are identified, and management objectives are developed in response to these challenges. Resource conservation priorities are established, and amendments to park zoning are identified. Finally, a strategy is developed to meet the management objectives identified in the plan. These are the elements that must be examined in more detail in the present CEA exercise.

The management plan provides background information on the park environment and management practices to date. It is those management practices and past park development that are examined in the 1991 EA summarized in the plan. That assessment, which was undertaken under EARPGO, provides a useful overview of the implementation of mitigation associated with past development proposals such as the scenic road, intensive-use areas, sport fishing, canoeing, trail use and maintenance activities. It examines the impacts of facilities and activities in the intensive-use areas and concludes that *“considered separately, the structure of the sites and their use do not have a very large impact on land-based ecosystems. However, the multiplicity and frequency of use in the back-country could have a long-term effect of non-negotiable cumulative impacts on the natural processes and the composition of the ecosystems (land-based and aquatic). The unspoiled character of this zone also risks being jeopardized.”* (Canadian Parks Service, 1991).

The assessment also identifies issues relating to external pressures such as acid precipitation and resource harvesting, and concludes that “*The cumulative effects of these pressures on a limited area constitute major constraints to recuperating and /or maintaining ecological integrity.*” (Canadian Parks Service, 1991). Mitigation identified includes the definition of ecological integrity criteria for the park and the monitoring of the state of the environment through the use of ecological indicators.

5.3.3 Strategic directions of the management plan

Strategic direction is provided through a statement on regional context; a statement of purpose of the park together with ten general management objectives; 39 sectoral objectives; a zoning plan; an action plan; and a general conclusion.

The plan acknowledges the role of the park as a major pole of visitor attraction in the region, and recognizes the need for a co-operative approach to harmonize development objectives. The two facets of park development, management of the environment and establishment of visitor facilities, are recognized within the context of the park purpose, which is to maintain for all time the representative area of the St. Lawrence-Great Lakes natural region. Objectives are defined to guide the harmonization of these potentially conflicting goals.

Objectives are proposed relating to specific sectors of park management, such as marketing

or recreational services; these tend to remain general in nature while reflecting overall policy. An action plan defines the strategies to be undertaken as a result of the direction provided. The actions are also general in nature and relate to the development of plans or the completion of research. A summary of the strategic direction provided in the plan is shown in Table 6.

<p style="text-align: center;">Table 6 Strategic direction provided by the La Mauricie National Park Management Plan: a summary</p>
<ul style="list-style-type: none"> * regional setting: role as a major pole of visitor attraction; * maintain for all time the representative area of the St. Lawrence-Great Lakes natural region; * prevent the deterioration of park resources; * integrate principles of the World Conservation Strategy; * communicate the "Laurentian Heritage" and the mandate of Parks Canada; * promote the understanding of human interactions with nature; * develop structures and facilities within the context of ecosystem protection; * provide safe facilities and universal access; * promote types of use which protect resources; * foster recreation, leisure and enjoyment of park resources; * harmonize surrounding land use with park goals; * encourage support services in surrounding municipalities. * respect the zoning plan; * undertake described actions

The Plan provides a zoning map to guide the use and management of park resources. The national parks zoning system is comprised of five zones: (1) special preservation; (2) wilderness; (3) natural environment; (4) outdoor recreation; and (5) park services. Each of these zones is represented within the park.

Zone 1, or special preservation areas, contains exceptional features such as rare or endangered species, or unique or representative examples of natural or cultural elements. Access is usually restricted and no motorized vehicles or human facilities are allowed. Only 2% of the park is zoned “special preservation”, including eight sites harbouring rare species, a representative portion of the shoreline of Lake Anticagamac, and the rock paintings at Lake Wapizagonke.

Zone 2 comprises most of the park (93%). This wilderness zone is intended to preserve natural features in an unspoiled state, offering visitors opportunities for solitude and quiet in a wilderness setting. Only primitive facilities are allowed and motorized vehicles are prohibited.

Zone 3 accounts for 3% of the park’s area, and supports more intensive outdoor activities that are consistent with a natural environment. Motorized vehicles are forbidden in these zones. Areas designated as Zone 3 include lakes Wapizagonke and Édouard, as well as a few specific areas supporting natural activities such as a multi-use trail and the Wabenaki Lodge.

Zone 4 makes up the 3% of the park where the most intensive recreational activities may take place, such as the scenic parkway, and the five high-intensity use areas along the parkway. Finally, Zone 5 includes park installations and facilities for visitor use and administration.

Other strategic direction provided by the management plan includes a series of conservation priorities identified in an appendix, and a reference to strategic directions prepared by the Quebec regional office, which include the importance of systematic identification of threats to ecological integrity, the need to draw up visitation objectives, and the importance of fostering public awareness.

5.3.4 Scoping first principles

The first consideration in the scoping involves establishing consistency with the overall policy umbrella. This is an important step at the planning level. To accomplish it, a series of first principles were developed from the existing legal and policy framework. These principles are as follows:

- safeguard and preserve natural areas (Act Amending the National Parks Act, R.S.C., 1988)
- promote public understanding, appreciation and enjoyment - National Parks Act; (R..S..C., 1988)
- primacy of ecological integrity - National Parks Act, 1988, section 5 (R.S.C., 1988)
- natural ecosystem functions - draft ecological integrity statement (Parcs Canada, 1996)
- habitat protection - draft ecological integrity statement (Parcs Canada, 1996)

- predominance of native species - draft ecological integrity statement (Parcs Canada, 1996)
- viable population levels - draft ecological integrity statement (Parcs Canada, 1996)
- intact ecosystem structures/functions - draft ecological integrity statement (Parcs Canada, 1996)
- air /water quality - draft ecological integrity statement (Parcs Canada, 1996)
- sustainable development of local communities - Guiding Principles and Operational Policies (Department of Canadian Heritage, 1994a)

The next step of the scoping involved determining whether the broad directions proposed in the management plan are consistent with the first principles identified. A matrix format was used for this purpose (Table 7).

Table 7 shows that the themes of the management plan are consistent with the umbrella policies and first principles. The role of the park as a major regional visitor attraction presents potential conflicts with most first principles; this does not necessarily denote a negative impact but simply the need for management. Similarly, the objective of fostering recreation could present conflicts depending on the manner in which it is interpreted. The zoning plan generally supports first principles, but the overwhelming predominance of Zone 2 over Zone 1 does not reflect the primacy of ecological integrity.

Table 7
Consistency of management plan themes with first principles

BROAD THEMES OF THE MANAGEMENT PLAN	preserve natural areas	promote understanding and enjoyment	primacy of ecological integrity	naturally functioning ecosystems	habitat protection	predominance of native species	viable population levels	intact structures and functions	air and water quality	sustainable local development
regional setting: role as major pole of visitor attraction	N	P	N	N	N	N	N	N	N	P
maintain representative area of St. Lawrence-Great Lakes region	P	P	P	P	P	P	P	P	P	P
prevent deterioration of park resources	P	-	P	P	P	P	P	P	P	P
integrate principles of World Conservation Strategy	P	-	P	P	P	P	P	P	P	P
communicate the "Laurentian Heritage" and Parks Canada's mandate	P	P	P	P	P	P	P	P	P	P
promote the understanding of human interactions with nature	P	P	P	P	P	P	P	P	P	P
develop structures and facilities within the context of ecosystem protection	-	P	-	-	-	-	-	-	-	P
safe facilities and universal access	-	P	-	-	-	-	-	-	-	P
promote types of use which protect resources	P	P	P	P	P	P	P	P	P	P
foster recreation, leisure, and enjoyment of park resources	N	P	N	N	-	-	-	-	-	P
harmonize surrounding land use with park goals	P	P	P	P	P	P	P	P	P	P
encourage support services in surrounding municipalities	?	P	?	-	-	-	-	-	-	P
park zoning plan	-	-	N	P	P	P	P	P	P	P
Action Plan	P	P	-	P	P	P	P	P	P	P

N = a potential conflict with first principles

P = support for first principles

? = insufficient information

- = neutrality

5.3.5 Scoping boundaries and key issues

The regional ecosystem was selected as the appropriate scale for the assessment of the management plan. The regional ecosystem was defined in the course of a workshop on ecological integrity (Parks Canada, 1993) on the basis of ecological districts, habitat requirements for wide-ranging species, spatial requirements associated with ecological processes such as fire, biophysical units, and land jurisdiction considerations.

Relevant temporal boundaries were more difficult to establish. It was deemed appropriate to consider changes which had occurred since the creation of the park; however, any trends of specific relevance to key components would be considered on a time scale established case-by-case.

Key components of the regional ecosystem were already identified in the Ecological Integrity Statement (Parcs Canada, 1996) and include:

- geological features of the Canadian Shield;
- a physiography of rounded hills and valleys, typical of the lower Laurentian region, transected by a rich hydrological regime;
- landscape and geomorphological phenomena associated with the last ice age;
- a system of lakes and rivers created by the last ice age;

- a flora typical of the transition between deciduous and coniferous forests:
- the presence of over 440 species of vegetation including 42 that are considered rare:
- an overall population of some 50 species of mammals characteristic of deciduous and coniferous forest habitats:
- an avifauna population of approximately 110 species nesting within the park; and
- the presence of top predators requiring large territories.

Regional stressors and major issues of concern were identified in the trail assessment workshop as well as the Draft Ecological Integrity Statement (Parcs Canada, 1996) and the Park Management Plan itself. These may be summarized as follows: atmospheric pollution, resource harvesting activities (hunting, trapping, fishing, and logging), habitat fragmentation resulting from agriculture and cottage development; fire suppression; use of Lac à La Pêche as a source of domestic water for the town of Shawinigan; log floating and booms on the Matawin and Saint-Maurice rivers; truck transport of logs along the main highway; selective cutting in maple forests for sugar bush production; the high level of visitation within the park; past management activities within the park; and sport fishing within the park.

5.3.6 Preliminary analysis

On the basis of the scoping described above, a preliminary analysis was undertaken to see how information could be organized for the assessment of the management plan. A summary

of the main features of this analysis is presented here.

One of the first steps of the analysis involved the identification of overall sources of stressors acting upon the regional ecosystem, and the identification of trends and patterns of such stressors. Stressors were examined in terms of potential temporal and spatial overlap. Temporal overlap was examined using a series of matrices developed for all types of human activities including visitor use, park management, illegal activities, and activities in the regional ecosystem. These matrices illustrated the temporal overlap in visitor activities within the park. It clearly shows the concentration of activities during the summer season.

Spatial overlap was examined using a similar set of matrices. For the purposes of this series of matrices, drainage basin subdivisions provided in the Park Summary and Analysis of Natural Resources (Environment Canada - Parks, 1981) were used to define sectors within the park and surrounding region. They revealed that park activities are concentrated in specific sectors, generally along the scenic parkway.

In a second step, major sources of stress acting upon the selected key components were identified, and linked through pathways to overall effects. Wherever possible, indicators and objectives were identified. These in turn were linked to the management actions required for their resolution, as shown in Table 8.

Table 8: Linking a cause-effect analysis to management actions required			
Stressors	Pathways and effects	Indicators	Objectives and management actions required
development outside park including roads, cottages, agriculture, urban development, and resource harvesting, noise from trucks, and human intrusions	additive, incremental fragmentation of regional landscape and changes in predator-prey relationships; isolation and loss of genetic diversity of populations, loss of species diversity	<ul style="list-style-type: none"> * black bear * timber wolf * moose * fisher * lynx 	Maintain viable level population levels: <ul style="list-style-type: none"> - undertake long-term monitoring - establish target population levels - negotiate agreements to limit hunting and trapping in adjacent territories - negotiate agreements for wildlife corridors - participate in regional sustainable development initiatives
interruption of natural processes such as by fire control, control of insect epidemics in the greater ecosystem, logging outside park	complex interactions resulting in changes to local landscape structure	<ul style="list-style-type: none"> * young forests * mature or over mature forests * transition zones and wetlands * top predators 	Maintain or re-establish dynamic equilibrium: <ul style="list-style-type: none"> - maintain a total area of 20% young forests - maintain a maximum total area of 30% mature forests - maintain ecotones and wetlands (no target established) - controlled-burn program - monitor top predators
past actions such as dams and log floating in park; current actions such as sport fishing, disturbance by canoeists, introduction of non-native species; external actions such as acid precipitation, pollutants and sedimentation from outside park, removal of domestic water	additive effect of acidification (17% of lakes acidified, 29% becoming acidified), complex interactions with other stressors results in overall degradation of aquatic habitats and loss of species diversity in aquatic systems	<ul style="list-style-type: none"> * pH of water * native brook trout * range of undisturbed aquatic systems 	<ul style="list-style-type: none"> - acid precipitation monitoring program - restore aquatic ecosystems - identify and protect critical habitat and keystone species - identify and protect rare species - set aside undisturbed aquatic ecosystems which will serve as baseline for future reference
high levels of visitation, temporal and spatial crowding of visitor activities	additive and incremental disturbance of fauna, erosion, introduction of non-native species, etc	<ul style="list-style-type: none"> * loon (vulnerable species) * purple loosestrife * ragweed (invasive non-native species) 	Determine carrying capacity levels or limits of acceptable change: <ul style="list-style-type: none"> - link carrying capacity levels to park zones for clear definitions of desired levels of use based on habitat and goals - monitor loon population - monitor invasive non-native species
acid precipitation, past logging in park	complex interactions leading to degradation of forests ecosystems, loss of species diversity		<ul style="list-style-type: none"> - identify critical habitats and rare species
all stressors	overall trends indicate a loss of ecological integrity within the park and regional ecosystems	set of indicators of ecological integrity	Integrated monitoring program of overall ecological integrity based on a set of indicators for the park: <ul style="list-style-type: none"> - identify indicators and complete ecological integrity statement - undertake monitoring

Table 8 provides the basis for assessing the extent to which the current management plan

responds to the issues created by the multiple stressors acting upon the regional ecosystem. This was undertaken by comparing components of the management plan and required management actions, shown in Table 9.

Table 9
Response of the Management Plan to required actions for dealing with cumulative effects

Management actions required	Strategic directions				
	regional setting statement	strategic objectives (10)	sectoral objectives (39)	zoning plan	action plan
negotiate agreements to limit adjacent hunting and trapping	P	-	P	C-1	-
participate in regional sustainable development initiatives	P	P	P	C-2	-
maintain dynamic equilibrium of local landscapes	-	P	P	-	P
monitor top predators	-	-	P	-	P
monitor effects of acid precipitation	-	-	P	-	P
set aside undisturbed aquatic ecosystems as a baseline reference	-	-	-	N	P
determine carrying capacity or limits of acceptable change for major effects	-	P	C-3	N	N
link capacity levels to park zones for clear identification of desired levels of use based on habitat and goals	-	C-4	C-5	N	N
identify critical habitats and rare species	-	-	C-6	C-7	P
identify indicators of ecological integrity for integrated monitoring	-	C-8	-	-	-

P= supportive of action required

N= not supportive of action required

C= referral to comments

- = neutral

Table 9 provides interesting material for analysis. Entries along a given row indicate the extent of response of the management plan to the actions required; mitigation may be required where the management plan fails to address the actions required, or where only one strategic direction addresses such critical issues. For example, the need to negotiate agreements to limit hunting and trapping is identified as a required management action in row 1; support for this action is noted in the regional setting statement and in the regional objectives, but is missing in the action plan. The zoning plan does not identify any critical habitat or provide sensitivity mapping outside park boundaries which would assist in the negotiations (C-1).

Actions required that relate to carrying capacity are highlighted in the seventh row. The regional setting statement recognizes that further development cannot be supported, but fails to define development. Under the strategic objectives, the plan states that park carrying capacity must be taken into account. However, the sectoral objectives (C-3) fail to provide clear direction. These objectives state that sport fishing management must be reviewed to allow “as many visitors as possible to enjoy this activity”; that the number of visits must be “optimized”; that a range of opportunities for visitors must be developed while maintaining the ecological integrity of the park; and that park marketing must emphasize off-season activities and increase the level of visitors from outside the region. The zoning plan is unhelpful in defining carrying capacity, since it fails to provide any indication of desirable levels of use associated with zones or sectors. Specific support for determining carrying

capacity is missing from the action plan. Thus, while there is a clear call for conducting “*environmental and social research needed to define and quantify the true carrying capacity of the park in order to optimize use while continuing to preserve resources*” (Canadian Parks Service, 1991), no actual thresholds or limits are identified in the management plan.

Column summations provide an indication of the usefulness of each broad direction of the management plan. For example, the regional setting statement (column 1), provides support to regional sustainability initiatives, and provides somewhat mitigated guidance on carrying capacity through the declaration that additional development within the park cannot be supported. What the statement fails to establish is whether this is determined on the basis of existing infrastructure or environmental considerations. If the plan interprets capacity in terms of infrastructure availability, it would lead to the perception that additional development would resolve the issues. The columns for strategic objectives, sectoral objectives and action plan suggest that, while these could be enhanced, they are useful elements of the management plan. Analysis of the column for zoning suggests that the zoning plan could be much more proactive in supporting key requirements and thus mitigating cumulative effects.

5.3.7 Preliminary recommendations

The preliminary analysis has provided insight into the potential consequences of the

management plan for La Mauricie National Park, as well as the approach for assessing the plan. While the proposals included in the plan support Parks Canada's principles and policy, a review of the directions *required* in a management plan suggests that there is room for improvement, most notably by developing specific direction relating to thresholds, overall ecological integrity, and harmonizing the goals of conservation and use.

The test case assessing cumulative effects at the project level has indicated that such guidance is necessary. The long-distance hiking trail raised questions about the acceptable levels of human intrusion in park backcountry and the cumulative effects of fragmentation on wide-ranging species that can only be adequately addressed through the management plan. The results of failing to confront such difficult issues would be continued incremental effects of human intrusion and gradual loss of ecological integrity.

5.3.8 Evaluating the test case

Following completion of the preliminary CEA of the La Mauricie National Park Management Plan, the test case was reviewed on the basis of the ten evaluation criteria:

- *Clarity of purpose:* On the basis of the approach provided, the assessment was undertaken in-house by Parks Canada staff from La Mauricie National Park, the Quebec regional office and Parks Canada headquarters. Direction provided by the

approach was clear and allowed the assessment to focus on key issues of concern.

- *Incorporation of broad perspective:* The approach used regional ecosystem boundaries and identified potential impacts relating to the broader perspective throughout the assessment.
- *Scope of application:* The test case demonstrated that the approach can be applied to the screenings of strategic proposals such as a park management plan.
- *Stakeholder involvement:* Public consultation is sought in the review of a park management plan as part of the management planning process; input on the EA is normally obtained at that time. In this preliminary CEA, internal stakeholders were consulted through the initial scoping workshop and a follow-up meeting held at the Quebec regional office.
- *Interjurisdictional:* Because the preliminary CEA focused on the regional ecosystem, interjurisdictional issues were raised. Although they were not investigated in detail at this stage, the approach provided for the analysis of such issues and they will be considered in greater detail in the course of the full EA.
- *Monitoring and feedback:* At the strategic level, the test case emphasized the importance of feedback especially in the areas of determination of thresholds for cumulative effects such as appropriate levels of use. Such thresholds can only be determined over time as information from park monitoring programmes provide required orientation for setting limits of use.
- *Timely input into decision making:* The test case was preliminary in nature and the

actual revision of the management plan has not yet been initiated. At the strategic level, however, several of the issues identified can only be dealt with on an ongoing basis as information is provided through monitoring and feedback. This suggests that, at least for park management plans, the CEA is most useful where results can be incorporated into a management planning process. Since the management plan is an expression of an ongoing management planning process, and is subject to regular revisions, it provides the necessary context for incorporating the information resulting from a cumulative effects assessment, ongoing monitoring and analysis updates.

- *Flexibility and adaptability:* The various steps of the CEA approach were adapted to the requirements of an assessment of a strategic proposal.
- *Cost-effectiveness:* The approach relied heavily on existing information and existing processes and made use of in-house expertise where applicable.
- *Insight for long-term direction:* The approach provided direction for decisions and orientation required in the short term for the development of the park management plan. At the same time, insight was provided into longer term strategies that must be undertaken to resolve some of the more difficult issues such as carrying capacity, that will become pressing in the medium to long term.

The above criteria suggest that the CEA framework is applicable to strategic proposals such as park management plans. Of note is the fact that the assessment highlighted certain key

issues, such as the critical need for establishing thresholds linked to zoning, without providing immediate answers. Because the potential impacts are broader in scope than for traditional EAs, the development of some solutions require more in-depth work. Thus, a cumulative effects assessments may not provide all the answers, but should put forth a strategy to obtain the solutions in the medium term.

5.4 TESTING THE APPROACH FOR MULTIPLE SMALL PROJECTS AT THE TRENT-SEVERN WATERWAY.

5.4.1 Rationale

Cumulative effects, when they have been considered at all, have usually been assessed in EAS of large projects. Given the number of cumulative impacts that originate from small, individually insignificant projects, an effective EA framework, like environmental assessment itself, must be applicable to the full range of projects that can eventually lead to environmental effects. The proposed CEA approach recommends that small, repetitive projects with individually minor but collectively significant effects should be grouped together and assessed collectively, scoping priority issues and developing appropriate standards to guide each individual project.

The Trent-Severn Waterway provides an ideal test case for this. Over 500 stormwater outlets

discharge into the waterway, most of which were installed gradually without specific authorization by Parks Canada (Jim Norris, pers. comm., 1996). The Trent-Severn Waterway management is currently undertaking a licensing system to generate revenue and improve the environmental message regarding stormwater outlets. Should such a system be implemented, each license would trigger an EA under the *Canadian Environmental Assessment Act*, along with a legal requirement to assess cumulative effects. At the same time, the Trent-Severn Waterway staff is faced with diminishing support from provincial agencies such as the Ontario Ministry of the Environment, that formerly monitored water quality and undertook remedial actions to a much greater extent than they do now. This makes the task of assessing cumulative effects much more difficult. These considerations, coupled with the high number of water quality variables involved and the broad geographical area covered, all point to the importance of an effective scoping exercise to ensure that the assessment of cumulative effects remains both manageable and effective.

5.4.2 Introduction to the Trent-Severn Waterway

The Trent-Severn Waterway is a navigable system of lakes, rivers and artificial channels which extends 386 km through south-central Ontario from Trenton on the Bay of Quinte to the Georgian Bay. The system crosses two major physiographic regions: the rolling farmlands of the Great Lakes-St. Lawrence Lowlands, and the more rugged terrain of the Precambrian Shield. It passes through four cities and many towns, villages, and

municipalities. The combined drainage basins of the Trent and Severn rivers are approximately 18,600 km².

Designated nationally significant in 1929, the waterway commemorates “*the role of the Trent Canal in opening up the interior of Ontario, and the Simcoe-Balsam Lake section for its large number of unmodified original structures*” (Environment Canada, 1991). It is managed by Parks Canada for the preservation and interpretation of natural and cultural heritage resources, and for recreational navigation; other management interests include power generation, flood control and fishing.

The water flow of the system is regulated by a total of 43 locks and 125 dams. Threats to the aquatic system have been identified as dredge and fill activities, loss of vegetation along the shoreline, deteriorating water quality, and increased recreational use (Environment Canada, 1991).

The Peterborough Reach is a section of the waterway that extends approximately 75 km from Lakefield north of Peterborough, along the Otonabee River through to Rice Lake. The City of Peterborough is located roughly halfway through this section. The Otonabee River is designated as a “Policy 2” river by the Ontario Ministry of Environment with respect to phosphorus concentrations, which signifies that no further loss of water quality is acceptable, and improvements should be pursued because of the sensitive nature of Rice Lake and the

Bay of Quinte downstream of Peterborough (CG&S, 1997).

5.4.3 Approach

The test case used a start-up workshop to scope issues of concern. While a range of stormwater components were identified, it was felt that special attention should be directed at two key components of the aquatic system - bacteria and total phosphorus within the Peterborough Reach. The assessment would provide recommendations as to comparable efforts necessary for other components of stormwater discharge.

Based on the CEA framework, the following steps were undertaken:

- 1. Scoping:
 - review policy context
 - identify main issues and concerns
 - focus on phosphorus and faecal coliform as key components
 - identify appropriate geographical and temporal boundaries
- 2. Analysis:
 - identify the most probable sources
 - focus on the main pathways of change
 - review any overall resulting trends in the waterway or relevant sections of the waterway
 - compare the relative contribution of stormwater outlets to the overall situation
 - develop any appropriate mitigation that can be applied to individual outfalls
- 3. Evaluation:
 - identify appropriate standards or thresholds for stormwater outfalls
 - evaluate the significance of the contribution of stormwater outfalls to the overall problems related to these variables in the Trent-Severn Waterway
- 4. Recommendations, follow-up and feedback:

- identify requirements, including alternative strategies for stormwater assessment and management
- identify considerations to guide the assessment of individual projects.

5.4.4 Results of the scoping

In most cases, the assessment of cumulative effects is hindered by the absence of relevant policies and thresholds. However, the policy context for stormwater is established through a plethora of legislation, policy, standards and procedures, including three federal acts, twelve provincial acts, the municipal planning act and various approval processes (CG&S, 1997).

Main issues and concerns identified included biological, physical, recreational and economic attributes of aquatic systems that have the potential for impacts from stormwater. High levels of total phosphorus were seen as most problematic since the resultant effects on water quality could lead to loss of species diversity or vulnerable aquatic habitats such as spawning grounds. Phosphorus contamination can also lead to algal blooms or the excessive growth of aquatic plants, which limit the potential for recreational activities such as boating and fishing. Bacterial contamination can result in beach closures but usually does not affect the viability of most aquatic organisms (CG&S, 1997). Municipal water supply will be affected by rises in both components, leading to higher water treatment costs.

The test case focused on total phosphorus and bacteria, although a range of contaminants is

associated with stormwater discharges, including suspended solids, nutrients (such as nitrates and nitrogen), ammonia, heavy metals, toxic pollutants (such as arsenic, phenols, oils and grease, hydrocarbons and Poly Aromatic Hydrocarbons or PAHs), and changes in oxygen demand and water temperature (CG&S, 1997). Total phosphorus and bacteria were selected because it was felt that an overall perspective was available for these key components in stormwater management, without a need for specific studies such as for toxic substances (Jim Norris, pers. comm., 1996). Availability of established standards and targets would facilitate the assessment of cumulative effects of such components, and the method developed could then be extended to other substances.

5.4.5 Analysis based on sources, pathways and consequences

Discharges from individual stormwater outfalls are mixed with upstream inputs as well as with contaminants from a variety of sources such as shoreline erosion, dredge and fill operations, or natural run-off. Future outlets and enlargements to existing outlets must also be considered as eventual additional sources of discharge. Land use was identified as a major contributing factor to stormwater contamination, as shown in Table 10.

Levels of contamination are weather-dependent. The intensity and duration of precipitation, coupled with prior weather conditions, will influence the type and quantity of runoff and infiltration.

Table 10 Typical concentrations of total phosphorus and faecal coliform in stormwater based on land use category (source: CG&S, 1997)		
Land Use	Concentrations	
	Total phosphorus (mg/L) ¹	Faecal coliform ² (mpn/100 mL)
Residential	0.28	21,000
Commercial (parking lot)	0.73	2,900
Industrial	0.75	49,000
Urban open space	0.68	5,600
Agricultural	0.14-91	0-1,000,000
Rural open space	< 0.1	< 10

¹ Typical concentration ranges for total phosphorus in stormwater are 0.3-0.4 mg/L

² Typical concentration ranges for faecal coliform in stormwater are 20-24,000 mpn/100 mL

The test case mapped all existing stormwater outlets and characterized the nature of the surrounding drainage areas, including 58 outlets draining urban lands, 15 outlets draining agricultural lands, and 3 outlets draining conservation lands. The majority of drainage within the Peterborough Reach occurs through tributary sources (879,700 hectares), while only 16,300 hectares drain directly into the waterway (CG&S, 1997). Upstream contaminant sources include agricultural runoff, livestock, cottages, direct stormwater discharges, and tributary stormwater discharges, as well as discharge from municipal water filtration and wastewater treatment plants.

The pathways of change leading to cumulative effects are different for phosphorus and

bacteria. Faecal coliform have a limited life span and generally do not interact with other elements of the aquatic system in complex manners. Pathways are therefore linear and additive, but die-off rates and travel time must be factored into the analysis. Multiple input sources will lead to higher levels of bacterial contamination downstream, especially after heavy rainfall, and will lead to impairment of use in areas affected (CG&S, 1997).

On the other hand, the pathways for phosphorus accumulation are complex and non-linear. Phosphorus accumulates in biological organisms, sediments and suspended particulate, and rates of uptake and release are dependent on existing water quality (CG&S, 1997):

“Because of the slow rates of uptake and release of phosphorus and the accumulation of phosphorus in the watercourse, the cumulative impacts of multiple discharges must be considered in an overall evaluation of the status of the watercourse. Generally, as the loading inputs of phosphorus increase, the quality of water decreases incrementally downstream of each successive discharge. This can result in significant areas of water quality degradation.” (CG&S, 1997)

In terms of bacterial contamination, background contamination from tributary and sources upstream from the City of Peterborough appear to be the major concern since long-term trends indicate a gradual but incremental rise in background bacterial levels (CG&S, 1997). The main cumulative effects of elevated levels of faecal coliforms from stormwater outlets are beach closures during significant rainfalls. Bacterial contamination returns to background levels after a few hours or days depending on rainfall patterns and flow rates in the river; the impact of contamination will be significantly reduced because of die-off rates which can reach 90% after 12 to 48 hours, depending on conditions such as water

temperature. Thus, bacterial contamination originating in the City of Peterborough will generally not significantly affect water quality downstream in Rice Lake (CG&S, 1997). This suggests that stormwater outlets in the vicinity of beaches should receive special attention in terms of potential cumulative effects.

The situation for phosphorus contamination is different. Typical concentrations of total phosphorus in stormwater outfalls are generally equivalent to ambient concentrations in the waterway (CG&S, 1997). Urban stormwater discharges are estimated to represent approximately 0.7% of the total phosphorus load into the Peterborough Reach (CG&S, 1997). Objectives of 20 ug/L for lakes and 10 ug/L for rivers have been established by the Ontario Ministry of the Environment as affording adequate protection from algal growth. Concentrations of phosphorous measured in the Otonabee River at Rice Lake range from 5 ug/L to 290 ug/L with a mean value of 29 ug/L (CG&S, 1997).

These figures suggest that while total phosphorus is a parameter of concern within the Peterborough Reach, the relative contribution from stormwater outlets is not significant. In terms of existing outlets, effective mitigation of phosphorus loading is difficult and expensive. As a result, greater benefits may be achieved at a much lower costs through reduction of equivalent loads elsewhere in the system, even where such reductions would be outside the jurisdiction of Parks Canada (CG&S, 1997).

5.4.6 Evaluation and recommendations

Four criteria were used to characterize stormwater outlets according to their potential contribution to overall cumulative effects: the size of the drainage area; the nature of surrounding land use; the implementation of “best management practices”; and the presence of sensitive features such as spawning sites. Drainage areas were classified into three categories: 1 to 5 hectares; 5 to 25 hectares; and 25+ hectares. The categories of land use identified are urban, rural/agricultural/cottage, and conservation (marsh, woodland, etc). Best management practices include reduction at source or discharge treatments such as retention ponds.

This classification identifies outlets that require more in-depth assessment in the course of the licensing process, and those that can be viewed as insignificant in terms of overall cumulative effects. The assessment recommends specific attention to the following category of outlets:

“We identify these as new outlets or ones in which there will be substantial land use change that are urban in land use, greater than 5 hectares and upstream of bathing beaches or concentrations of water contact recreationists. The cumulative effects of concern in this case show the potential for ‘nibbling’ and effects distant in time or space. In conclusion, we did not find the TP [Total Phosphorus] nibbling to be significant and bacteria only an issue in specific circumstances” (CG&S, 1997).

However, since overall trends indicate a gradual loss of water quality which is approaching the limits of what is considered acceptable, an integrated approach to water quality

management is needed to minimize or prevent cumulative effects. The assessment recommended the following measures:

1. Extend the assessment of the relative contribution of stormwater outlets to total phosphorus along the entire length of the waterway;
2. Study the vulnerability of receiving waters to bacterial loading;
3. Identify lands slated for future urban growth or re-development;
4. Require the preparation of a subwatershed or master drainage plans as a condition of licensing within those lands;
5. Encourage best management practices as a licensing requirement for stormwater outlets;
6. Implement a phosphorus trading program to offset inputs from stormwater outlets in the Peterborough Reach;
7. Monitor major outlets for phosphorus and toxics;
8. Adopt a cooperative approach with federal departments, provincial ministries and agencies, and municipalities; and,
9. Review the data periodically.

In conclusion, the assessment noted that the Trent-Severn Waterway's contribution to the overall water quality problems within the watershed is minimal, and ultimately, solutions must be developed with the active participation of partners who have a greater stake in the

problems. Thus, the assessment provides guidance for the immediate question of licensing stormwater outlets, while pointing at the directions which must be explored co-operatively to deal with the bigger picture.

5.4.7 Evaluating the test case

The Trent-Severn test case was evaluated based on the ten criteria previously identified:

- *Clarity of purpose:* The assessment was undertaken by a consultant, with the assistance and guidance of staff from the Trent-Severn Waterway and Parks Canada headquarters. Although the assessment represents a partial CEA only, based on two key components within the Peterborough Reach, the results suggest that it could be extended to include other components as required.
- *Incorporation of broad perspective:* The approach provided an opportunity to focus beyond the local surroundings of stormwater outlet. Although scoping identified the Peterborough Reach as the area of concern, information was also used from a broader perspective to provide insight into the health of the aquatic system.
- *Scope of application:* The test case provides an example of the application of the approach to small repetitive projects leading to collective impacts of concern.
- *Stakeholder involvement:* In the phase of the cumulative effects assessment undertaken in the test case, consultation was limited to Parks Canada staff and

officials from the provincial Ministry of Environment and Energy. Recommendations included broader consultations in the medium term.

- *Interjurisdictional:* Interjurisdictional issues were raised in the course of the assessment. Recommendations include the adoption of a cooperative approach with federal departments, provincial ministries and agencies, and municipalities.
- *Monitoring and feedback:* It is interesting to note that although several sources of data were available for this test case, little integrative information was available. The importance of a co-operative approach to monitoring water quality was emphasized.
- *Timely input into decision making:* The test case was preliminary in nature but provided timely information for the immediate management issues at hand. At the same time, longer term direction was provided for eventual overall issues that will need to be addressed to resolve ongoing questions of water quality trends. There is no indication, however, whether such long-term co-operative initiatives can be undertaken in a timely manner and to what extent co-operative ventures can be easily set up.
- *Flexibility and adaptability:* The test case demonstrated that the CEA approach can be applied to a grouping of small project assessments.
- *Cost-effectiveness:* The approach relied heavily on existing information and existing processes and made use of in-house expertise where applicable. Although in this sense it was cost-effective for resolving the shorter term issues concerning stormwater outlets, several of the long term recommendations will be very costly to

implement.

- *Insight for long-term direction:* The approach provided direction for decisions relating to stormwater management in the short term, while providing insight into longer term endeavours to adequately address cumulative issues of water quality.

The above criteria suggest that the CEA framework is applicable in the context of small, repetitive projects with impacts that cannot adequately be assessed on an individual basis. The long-term orientation provided to address cumulative water quality issues, however, is beyond the jurisdiction of the Trent-Severn Waterway to implement and must be approached on a co-operative, interjurisdictional basis. Because of the costs and harmonization efforts required, it is as yet uncertain whether the proposed solutions will be implemented in the long term.

5.5 CHAPTER CONCLUSIONS AND NEXT STEPS

Chapter 5 has presented the results of three test cases undertaken to evaluate the approach provided earlier. The test cases were selected to consider a range of examples under various circumstances including a “typical” project within Parks Canada, a strategic proposal, and a number of small, repetitive projects.

The final chapter presents the conclusions of the thesis.

CHAPTER 6

CONCLUSIONS

6.1 INITIAL CONSIDERATIONS

6.1.1 Is the approach necessary?

The investigation into the theory of CEA has clearly shown that assessing cumulative effects is a necessary component of good EA and an important tool in support of environmental sustainability. In the case of Parks Canada, many of the threats to ecological or commemorative integrity of heritage areas are cumulative in nature and it is imperative that they be addressed.

Despite recent legislation that confers a legal obligation upon federal authorities to assess the cumulative effects of projects, CEA is only slowly being integrated into common EA practice. The assessment of cumulative effects usually occurs at the panel or comprehensive study level: even with large projects, cumulative effects can be so difficult to address that issues raised in assessments have triggered specific regional studies. Yet, over 90% of environmental assessments undertaken at the federal level are project screenings, often involving small projects for which it would be unmanageable to undertake large EAs. Such small projects can and do contribute to cumulative effects. The current situation, then, is one where most small projects and many large ones are being assessed with only an incomplete

grasp of the cumulative effects. Clearly, an approach is needed to provide the structure for considering the bigger picture at every level of decision making. The conceptual framework and approach for cumulative effects assessment presented in this thesis address a very real need in this respect.

6.1.2 Is the approach solid?

The conceptual framework was developed based on a thorough investigation of current directions and thought in the field of cumulative effects assessment, a review of current practice in CEA, and input from concurrent case studies. The literature review resulted in the development of four guiding principles which recognize: the importance of tiering EAs and linking the various levels of decision making; that the land use/management planning level is the most opportune for considering broader spatial and temporal scales and guiding decision making at all levels; that key components and indicators can help focus on the relevant trends, thresholds or limits that are so important in assessing cumulative effects; and that uncertainty is unavoidable and must be controlled through adaptive management, monitoring and feedback, and professional judgement.

These principles provide a solid basis for the conceptual framework, which is based on an ecosystem approach using ecological and commemorative integrity as endpoints to management. The framework itself involves an analysis based on cause-effect linkages and

provides an evaluation based on whether changes are moving the system towards or away from a current state of integrity.

In turn, the framework provides a solid basis for the step-by-step approach that provides broad practical direction for assessing cumulative effects. The steps are not independent, discrete measures to be undertaken in sequence: rather, they are an iterative and dynamic series of interrelated actions, each providing feedback to the others, which ultimately contribute to the overall goal. The step-by-step approach provides a range of options to practitioners who can then adapt the process to the specific requirements of the proposal being assessed. It is therefore possible to conclude that the approach is solidly anchored in both theoretical and practical explorations of the concept of cumulative effects.

6.2 CONCLUSIONS FROM THE TEST CASES

6.2.1 Usefulness of the approach

The environmental assessment process at Parks Canada is well established, and it is now common practice to consider environmental effects of an action prior to implementation. Assessing cumulative effects simply involves taking this process one step further. The case studies and test cases suggest that this goal is certainly possible.

Environmental assessment is an evolving practice, and it would be utopic to imagine that cumulative effects assessment, which is still in its infancy, can successfully resolve all broader issues and incremental effects of past and present human activity. EAs must be kept manageable and some issues will need to be resolved through other fora. It is more realistic to aim for achieving sound assessments, reflecting the true context in which proposed activities would occur, and using best available methods, tools, and information, to guide decision makers towards wiser, more informed choices, despite the uncertainties inherent in the process. This is the fundamental purpose of environmental assessment, and this must be the gauge by which we determine whether CEA has been worthwhile. Ultimately, the benefits of any approach must be judged through practice. In this context, it is the test cases that provide an indication of the usefulness of the approach.

The CEA undertaken for the proposed long-distance hiking trail in La Mauricie National Park raised fundamental questions which were not addressed through the traditional EA. The assessment did not solve the question of optimal levels of use for backcountry in small parks; however, it did flag the issue and bring it to the park management planning level. At the same time, the assessment dealt with the immediate issue at hand: based on best professional judgement, it was determined that the proposed levels of use were such that the project itself when considered in the broader perspective of human activities and changes to the ecosystem, would not lead to serious adverse effects. Mitigation was recommended that reduced the potential effects identified, the trail alignment was modified, and the importance

of the quota system emphasized to limit the potential threats from future growth. Thus, it can be concluded that the assessment of cumulative effects was a useful exercise.

The management plan test case was a preliminary scoping and analysis rather than a complete environmental assessment; however, it addressed the challenge of reviewing a strategic proposal. Where a conventional approach would have examined the potential impacts stemming from any specific proposal contained in the plan, the cumulative effects perspective examined current trends and issues resulting from existing stressors acting upon the park in order to identify whether or not the plan responded to them. Preliminary findings suggest that more specific thresholds or limits, and changes to the zoning plan, would do much to minimize adverse cumulative effects. This information will be useful for the review of the management plan and the accompanying environmental assessment.

The final test case involved a preliminary assessment to gain a collective perspective of a large number of small projects which would be individually insignificant. This required the integration of large amounts of information. The exercise identified the potential cumulative effects resulting from stormwater outfalls and characterized the outfalls that could potentially contribute to those effects. This provides a focus for potential licensing considerations for future stormwater outfalls, and identified the most efficient mitigation for phosphorus loading. While more work is needed to control cumulative effects along the waterway, the assessment provides a valuable first step in the overall strategy required.

It can therefore be concluded that the CEA approach provides insight that will be useful to decision makers. It must be recognized, however, that some of the long term recommendations may prove challenging to implement: this is especially true in the case of the Trent-Severn Waterway where several actions were recommended that are beyond the jurisdiction of Parks Canada. In the case of La Mauricie National Park, while it was determined that the proposed trail will not significantly contribute to the fragmentation of wolf habitat, external factors are a cause of considerable concern¹. The difficulties subsequently experienced by the wolf population from hunting and trapping activities outside the park suggest that the broader issues are indeed critical.

This confirms that CEA alone is not sufficient to address cumulative effects. The potential problems lie not with the assessments themselves, but with the need for co-operation between agencies, for communicating results to the various levels of decision making, and for developing and working towards common goals and objectives. These are not technical challenges; they are political and social ones.

6.2.2 Effectiveness of the approach

The ten evaluation criteria developed in Chapter 1 provide insight into the effectiveness of

¹There is an as-yet unconfirmed report that as many as seven wolves were trapped in areas adjacent to the park over the winter of 1996/97 (Jean-François Villemure, pers. comm., 1997). If this is correct, the wolf population of the park has been severely decimated.

the conceptual framework and approach for CEA. First, the test cases demonstrate that the approach provides clear direction and can be implemented by Parks Canada staff or external consultants. The approach provides for a broad scope of application including large and small projects as well as strategic proposals. The perspective provided by the approach went beyond the local, traditional view of environmental impacts: this was particularly well illustrated by the long-distance hiking trail test case, which identified issues that had not been raised in the EA. All three test cases involved a scoping workshop attended by key stakeholders: although public consultation was not held as part of the cases, it would be included where required as an important element of the EA process itself. Similarly, while it was beyond the scope of the test cases to enter into cross-jurisdictional harmonization agreements, all three cases examined issues that were beyond Parks Canada's jurisdiction, and the need for eventual harmonization initiatives to deal with long-term issues was recognized.

Monitoring and feedback are integral components of the approach, and serve as tools for dealing with uncertainty and as techniques for referring issues to appropriate levels of decision making. For example, when the assessment of the proposed long-distance hiking trail raised the question of acceptable levels of use and fragmentation of habitat in previously inaccessible backcountry, feedback to the management planning level was essential for eventual resolution of these broader issues. In concluding that proposed levels of use of the trail would not lead to loss of ecosystem integrity, monitoring was identified as a

requirement. Results of the monitoring programme will be important to management planning and to validation of project-level decisions. This feedback between decision-making levels is key to the success of the approach and the framework for assessing cumulative effects must fit into existing management processes. The insight provided for the long-term directions, and how this is eventually implemented, will determine to what extent the framework helps achieve environmental sustainability.

The approach used for all three test cases was adapted to the specific conditions of each proposal. The step-by-step approach provides general direction but the emphasis placed on each step, and the tools and techniques used, will vary according to the needs of the assessment and the knowledge and preferences of the practitioner. The approach thus meets the requirements for flexibility and adaptability.

Available information was used in all three test cases thus minimizing costs and providing value for money. However, implementation of the long-term recommendations will involve additional analysis, harmonization initiatives and monitoring, all of which involve financial commitments. The cost-effectiveness of such measures can only be determined over time; there is little doubt, however, that prevention is much more cost-effective than cure, and the benefits of mitigating cumulative effects far outweigh the costs of continued incremental losses of environmental quality.

6.2.3 Support for first principles

From an overall perspective, the case studies lend support to the four guiding principles. Firstly, all three cases support the importance of tiering. For example, in the absence of a management plan, no forum would have been available for determining acceptable levels of use in the backcountry and to attempt to do so at the project level would have expanded the scope of the assessment beyond the scope of the project. Providing guidelines on thresholds or appropriate levels of use can more effectively be achieved at the management planning level; this allowed the trail assessment to remain manageable by scoping project-level issues and relevant key components. The La Mauricie test case also illustrated how project-level assessments can identify issues requiring attention at broader levels. A real-life situation can provide a focus on issues which would otherwise remain theoretical and nebulous at conceptual levels. This supports the need for feedback in all directions.

Secondly, in all three cases broader issues identified could best be addressed from the ecosystem management level. Thus, while the CEA approach allowed the potential effects of stormwater outlets to be scoped sufficiently to guide local choices, the development of subwatershed or master drainage plans was recommended as the optimum solution to address cumulative effects.

Thirdly, in all three cases the assessments were successful primarily because of the ability

to focus on key components and indicators. In the case of La Mauricie, targets and thresholds were not known but existing trends indicated that the ecological integrity of the park is threatened by past and current activities. In the case of the Trent-Severn Waterway, both trends and thresholds were important because of the availability of water quality standards.

Fourthly, all test cases presented varying levels of uncertainty and all supported the principle of using best available information and best professional judgement. In the case of the proposed hiking trail at La Mauricie, the lack of accepted guidelines on habitat fragmentation meant that consultation with experts and professional judgement offered the only means of evaluating the significance of the potential effects. Monitoring was identified as key to validating the assumptions made in the course of the CEA.

6.3 LESSONS LEARNED

The test cases provided valuable insight into cumulative effects assessment. They invariably raised broader issues which had the potential to greatly extend the scope of the assessment. CEA ultimately requires a judgement call to determine whether the information available is sufficient to deal with the immediate choices presented by the proposal under review. Effective CEA also requires that, when broader issues are raised through a proposal assessment, they be referred to an appropriate avenue for their eventual resolution. Feedback

to management and decision-making processes is therefore essential. Since many of the issues raised cross political jurisdictions, multi-jurisdictional forums will ultimately be required to adequately deal with them.

It may be difficult to judge when the broader issues raised are truly beyond the scope of the decision being considered, and must therefore be referred to another forum. In some cases this may be quantifiable; for example, the Trent-Severn test case determined that stormwater outlets contributed less than 1% of the phosphorus loading within the Peterborough Reach, which was judged insignificant in relation to the overall problem. In some cases, projects may need to be put on hold while critical overarching issues are resolved. This may be most difficult when dealing with small projects that are not repetitive in nature: again the land use planning/management level is essential to establish overall limits.

The establishment of limits, however expressed, remains one of the fundamental challenges for cumulative effects assessment. In some cases, limits may be acknowledged without determining specific thresholds when trends appear relatively stable. In other cases, it may be apparent that a critical threshold is close to being reached even though the limit has not been quantified. Determining thresholds is difficult, and frequently involves balancing scientific data and values and mediating conflicting goals. However, it is important not to lose sight of the fundamental purpose of EA which is to support informed decision making. Policy conflicts and controversies over values must be addressed in the proper areas.

It is of note to consider that, in the test cases undertaken, lack of information did not present as great a problem as anticipated. While frequently descriptive rather than integrative, the available information was nonetheless sufficient to consider overall trends and to establish broad cause-effect linkages that were adequate for the level of decision involved.

One of the challenges that arose in the test cases involved determining the significance of the contribution of a given proposal to overall trends. In the case of La Mauricie National Park, what is the significance of even minimal disturbance to relatively large inaccessible areas given the existing level of fragmentation of the regional ecosystem? This is similar to determining the significance of stormwater contributions to deteriorating water quality when their combined contribution to phosphorus loading is less than 1%. The key may lie in examining where modification and mitigation are most effective. For the wolf population in the La Mauricie regional ecosystem, an increase in users and increased interpretation efforts may lead to increased public pressure to halt trapping, which would more than offset the potentially minimal effects of the trail. Similarly, the expenditure of equal amounts of money upstream in the Trent-Severn Waterway may lead to truly significant lowering of phosphorus levels, whereas modifications to stormwater outlets would be expensive and yield comparatively little result.

Finally, given the levels of uncertainty and the importance of professional judgement in cumulative effects assessment, consultations with experts, workshops, peer review, and

scientific advisory teams may provide guidance in dealing with some of the challenges that will inevitably arise.

In conclusion, cumulative effects assessment at all levels of decision making is not only possible, but highly beneficial. The proposed principles, conceptual framework and step-by-step approach provide useful and solid guidance to EA practitioners for the assessment of cumulative effects in a variety of contexts.

6.4 LOOKING TO THE FUTURE

Parks Canada is now well on its way to incorporating the assessment of cumulative effects within standard EA practice. However, a collaborative approach is required to adequately address cumulative effects on heritage areas and elsewhere. The development of CEA frameworks within different agencies is encouraging. The Canadian Environmental Assessment Agency is currently preparing a practitioner's guide to CEA with the assistance of an independent Working Group of EA specialists. In the US, the Council of Environmental Quality has recently developed a guide to assessing cumulative effects under NEPA (CEQ 1996).

It is hoped that co-operative efforts will increasingly become the norm as overarching issues and questions are raised through environmental assessments. Multi-stakeholder groups will

be required to develop common goals and objectives. Guidelines will be required to assist in establishing the significance of predicted cumulative change, and to help establish responsibility and accountability frameworks. Data management systems will be required to promote the exchange of information and the updating of data. Finally, since overarching issues relating to cumulative effects are often best addressed at the land use planning/ecosystem management levels, special attention should be paid to implementing CEA at strategic levels of decision making.

REFERENCES

- Alberti, Marina, and Jonathan D. Parker, 1991. **"Indices of Environmental Quality: The Search for Credible Measures"**. *Environmental Impact Assessment Review* 11: 95-101.
- Armour, A., 1990. **"Integrating Impact Assessment in the Planning Process: From Rhetoric to Reality"**. *Impact Assessment Bulletin* 8:3-14.
- Bardecki, Michael J., 1994. **"Policies and Procedures for Cumulative Impact Management"**. pp. 355-368 *in*: Audrey, Jean, and J. Gordon Nelson, editors, 1994. *Public issues: A Geographical Perspective*. Department of Geography publication series no. 41, University of Waterloo; papers presented at a special session on public issues at the Annual General Meeting of the Canadian Association of Geographers held in Vancouver, May 1992.
- Barrett, Suzanne, and Joanna Kidd, 1991. **"Pathways: Towards an Ecosystem Approach"**. A report of Phases I and II of an Environmental Audit of Toronto's East Bayfront and Port Industrial Area, prepared for the Royal Commission on the Future of the Toronto Waterfront, April 1991.
- Baskerville, Gordon, 1986. **"Some Scientific Issues in Cumulative Environmental Impact Assessment"**. pp. 9-14 *in*: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).
- Beanlands, Gordon, 1992. **"Cumulative Effects and Sustainable Development"**. A paper presented at the United Nations University International Conference on the Definition and Measurement of Sustainability: the Biophysical Foundations. Washington D.C., June 22-25.
- Beanlands, Gordon E., and Peter N. Duinker, 1983. **"An Ecological Framework for Environmental Impact Assessment in Canada"**. Published in cooperation with the Federal Environmental Assessment Review Office and the Institute for Resource and Environmental Studies at Dalhousie University.
- Bedford, Barbara L., and Eric M. Preston, 1988. **"Developing the Scientific Basis for Assessing Cumulative Effects of Wetland Loss and Degradation on Landscape Functions: Status, Perspectives, and Prospects"** *in*: *Environmental Management* 12(5): 751-771
- Bennett, Judith, 1994. **"Strategies and Opportunities for Cumulative Effects Mitigation in Canada"**. pp. 103-117 *in* *Cumulative Effects Assessment in Canada*:

From Concept to Practice. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Berger, T.R., 1977. **"Northern Frontier, Northern Homeland: the Report of the Mackenzie Valley Pipeline Inquiry"**. Department of Supply and Services, Ottawa, Canada.

Bouin, Thierry, 1993. **"Management Concerns and Objectives of La Mauricie National Park"** in: Parks Canada, 1993. *"The Ecological Integrity of La Mauricie National Park: A Week of Reflection"*. Workshop Summary, February 22 to 26, 1993.

Bradley, Kevin, 1996. **"A Study Examining the Relationship Between the Social and Ecological Carrying Capacity for Backcountry Use at Pukaskwa National Park"**. Honours Project, School of Outdoor Education, Parks and Tourism, Lakehead University.

Bregha, François, Jamie Benidickson, Don Gamble, Tom Shillington and Ed Weick, 1990. **"The Integration of Environmental Considerations into Government Policy"**. A report prepared for the Canadian Environmental Research Council, September 1990.

Bronson, E., S.K. Sears and W.M. Paterson, 1991. **"A Perspective on Cumulative Assessment"**. Report No. 91016. Environmental Studies and Assessments Department, Ontario Hydro, Toronto.

Burdick, David M., Douglas Cushman, Robert Hamilton and James G. Gosselink, 1989. **"Faunal Changes and Bottomland Hardwood Forest Loss in the Tensas Watershed, Louisiana"**. *Conservation Biology* 3(3): 282-292.

Cada, G.F. and C.T. Hunsaker, 1990. **"Cumulative Impacts of Hydropower Development: Reaching a Watershed in Impact Assessment"**. *Environmental Professional* 12(1):2-9.

Cairns, John J., 1986. **"Freshwater"**. pp. 39-43 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Canadian Parks Service, 1991. **"Management Plan - Revised - La Mauricie National Park"**. Planning Service, October, 1991.

Cartwright, T.J., 1991. **"Planning and Chaos Theory"**. *Journal of the American Planning Association* 57(1): 44-56.

CEARC and U.S. NRC. (ed), 1986. **"Cumulative Environmental Effects: A Binational**

Perspective” workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

CEARC, 1988. **“The Assessment of Cumulative Effects: A Research Prospectus”**. Canadian Environmental Assessment Research Council, 1988.

CCME, 1987. **“Water Quality Guidelines”**. Canadian Council of Ministers of the Environment.

CCME, 1996. **“A Framework for Developing Ecosystem Health Goals, Objectives and Indicators: Tools for Ecosystem-based Management”**. Produced by the Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment. Winnipeg, Manitoba.

CEQ, 1983. **“Guidance Regarding NEPA Regulations”** Council on Environmental Quality, United States Federal Register 48. Washington, D. C.

CEQ, 1996. **“Considering Cumulative Effects Under the National Environmental Policy Act”**. Council on Environmental Quality, final draft, September 1996.

CG&S, 1997. **“Cumulative Effects of Stormwater Outlets Along the Trent-Severn Waterway: A Practical Approach”**. Draft report prepared for Parks Canada by CH2M Gore and Storrle Limited, Waterloo, Ontario, April 1997.

Clark, William, 1986. **The Cumulative Impacts of Human Activities on the Atmosphere**. pp. 113-123 *in*: CEARC and U.S. NRC, editors, 1986. *“Cumulative Environmental Effects: A Binational Perspective”* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Cocklin, Chris, 1993 **“What Does Cumulative Effects Analysis have to do with Sustainable Development?”**. *in*: *Canadian Journal of Regional Science* 16(3): 453-479.

Cocklin, Chris, and Sharon Parker, 1991. **“Planning for Cumulative Environmental Change”**. *in*: *Aspects of Environmental Change*, edited by Johnston, T.R.R., and J.R. Flenley. Department of Geography, Miscellaneous Series, Massey University.

Cocklin, Chris, Sharon Parker and John Hay, 1992a. **“Notes on Cumulative Environmental Change 1: Concepts and Issues”**. *Journal of Environmental Management* 35: 31-49

Cocklin, Chris, Sharon Parker and John Hay, 1992b. **“Notes on Cumulative**

Environmental Change II: A Contribution to the Methodology". Journal of Environmental Management, 35: 51-67

Colnett, Dianna, 1991. **"Integrating Cumulative Effects Assessment with Regional Planning"**. Prepared for the Canadian Environmental Assessment Research Council, January 1991.

Consulting and Audit Canada, 1995. **"What Tourism Managers Need to Know. A Practical Guide to the Development and Use of Indicators of Sustainable Tourism"**. prepared for the World Tourism Organization, September, 1995.

Contant, C., and L. Wiggins, 1991. **"Defining and Analysing Cumulative Environmental Impacts"** Environmental Impact Assessment Review, 11: 297-309.

Costanza, R., 1992. **"Toward an Operational Definition of Ecosystem Health"**. pp. 239-256 in: Costanza, Robert, Bryan G. Norton, and Benjamin D. Haskell, editors, 1992. *"Ecosystem Health: New Goals For Environmental Management"*. Island Press, Washington, D.C.

Culhane, Paul J., Paul Friesema, and Janice A. Beecher, 1987. **"Forecasts and Environmental Decision Making - The Content and Predictive Accuracy of Environmental Impact Statements"**. Social Impact Assessment Series, No. 14. Westview Press, Boulder, CO.

Daly, Herman E., and John B. Cobb, Jr., 1989. **"For the Common Good"**. Beacon Press, Boston.

Davies, K., 1991. **"Sourcebook of Cumulative Environmental Effects"**. Prepared for the Federal Environmental Assessment Review Office by Ecosystems Consulting Inc., Ottawa, Ontario.

Davies, K., 1992. **"An Advisory Guide on Addressing Cumulative Environmental Effects Under the Canadian Environmental Assessment Act: A Discussion Paper"**. Prepared by Ecosystems Consultants Inc. for the Federal Environmental Assessment Review Office, Hull, Quebec.

Dayton, Paul K., 1986. **"Cumulative Impacts in the Marine Realm"**. pp. 79-84 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Department of Canadian Heritage, 1994a. **"Guiding Principles and Operational**

Policies". Minister of Supply and Services, Canada, 1994.

Department of Canadian Heritage, 1994b. **Parks Canada Guide to Management Planning**. internal document, November, 1994.

Department of Canadian Heritage, 1995. **"Initial Assessment of Proposed Improvements to the Trans-Canada Highway in Banff National Park. Phase IIIA Sunshine Interchange to Castle Mountain Interchange"**. Parks Canada, March 1995.

Department of Canadian Heritage, 1996. **Procedures of the Department of Canadian Heritage for Complying with the *Canadian Environmental Assessment Act***. Approved March 1996

Dias, Oswald, and Brian Chinery, 1994. **"Addressing Cumulative Effects in Alberta: The Role of Integrated Resource Planning"**. pp. 303-317 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Dickert, T.C., and A.E. Tuttle, 1985. **"Cumulative Impact Assessment in Environmental Planning: A Coastal Watershed Example"**. *Environmental Impact Assessment Review* 5: 37-64.

Dixon, Jennifer, and Burrell E. Montz, 1995. **"From Concept to Practice: Implementing Cumulative Impact Assessment in New Zealand"**. *Environmental Management* 19(3): 445-456.

Doyle, Derek. 1994. **"Addressing Cumulative Environmental Effects in Canadian Environmental Assessment"**. Presentation to workshop seminar on environmental assessment under the Canada/Hong Kong Environmental Cooperative Agreement, Hong Kong March 7-11, 1994.

Doyle, Derek, and Barry Sadler, 1996. **"Environmental Assessment in Canada. Frameworks, Procedures and Attributes of Effectiveness"**. A report in support of the International Study of the Effectiveness of Environmental Assessment. Canadian Environmental Assessment Agency and UMA Engineering.

Drouin, Carmen, and Patrice LeBlanc, 1994. **"The Canadian Environmental Assessment Act and Cumulative Environmental Effects"**. pp. 25-36 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Duinker, Peter, 1994. **"Cumulative Effects Assessment: What's the Big Deal?"** pp.

11-24 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists: edited by Alan J. Kennedy, 1994.

Duval, Wayne, and Patricia Vonk, 1994. **"A Semi-Quantitative Procedure for Preparation of Initial Environmental Evaluations and Assessment of Potential Impact Significance"**. Axys Environmental Consulting Ltd., Vancouver, B.C.

Eccles, Ross, Jeff Green, Russell Morrison, and Alan Kennedy, 1994. **"Approaches to Cumulative Effects Assessment of Petroleum Development in Alberta"**. pp. 189-196 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists: edited by Alan J. Kennedy, 1994.

Elkin, Timothy J., and Paul G.R. Smith, 1987. **"What is a Good Environmental Impact Statement? Reviewing Screening Reports from Canada's National Parks"** *Journal of Environmental Management* (1988)26: 71-89.

Environment Canada, 1988. **Getting Started - A Guide to Service Planning**. Canadian Parks Service, internal handbook, June 1988.

Environment Canada, 1991. **"State of the Parks 1990 Report"**. Canadian Parks Service, Minister of Supply and Services Canada 1991.

Environment Canada, 1993. **"Guidelines for the Management of Archaeological Resources in the Canadian Parks Service"**. Prepared by the National Historic Sites Directorate, Archaeological Research Branch, Archaeological Resource Management Program Section and Regional Archaeology Offices, Canadian Parks Service.

Environment Canada, 1996. **"The Ecosystem Approach: Getting Beyond the Rhetoric"**. Produced by the Task Group on Ecosystem Approach and Ecosystem Science, September 1996

Environmental Resources Limited, 1985. **"Handling Uncertainty in Environmental Impact Assessment: Final Report - Handling Uncertainty in Predictions"**. prepared for the Ministry of Public Housing, Physical Planning and Environmental Protection, April 1985.

Erckmann, James W., 1986. **"Commentary II"**. pp. 19-21 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

FEARO, 1992. **“Developing Environmentally Responsible Policies and Programs: A Sourcebook on Environmental Assessment”**. Federal Environmental Assessment Review Office: Final draft, January 13, 1992.

FEARO, 1993a. **“Addressing Cumulative Environmental Effects: A Reference Guide for the Canadian Environmental Assessment Act”** Federal Environmental Assessment Review Office: Responsible Authority’s Guide, Ottawa, Minister of Supply and Services, 1993.

FEARO, 1993b. **“The Environmental Assessment Process for Policy and Program Proposals”**. Federal Environmental Assessment Review Office, February, 1993.

Gamble, D.J., 1979. **“Destruction by Insignificant Increments”** Northern Perspectives 7:1-4.

Gartner, J.F., Tom Hilditch, and Ron Hubbard, 1994. **“Functional Assessment Framework for Cumulative Effects Assessment in Ontario”**. pp. 135-147 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Gaudet, Connie L., Michael P. Wong, Amanda Brady, and Robert Kent, 1997. **“The Transition from Environmental Quality to Ecosystem Health”**. Ecosystem Health 3(1):3-10 (March 1997).

Geomatics International, 1996a. **“Principles and Standards for Ecosystem-Based Management for Parks Canada”**. Prepared for Canadian Heritage - Parks Canada, Natural Resources Branch, December 1996.

Geomatics International, 1996b. **“Bruce Peninsula National Park - Cumulative Effects Assessment Framework”**. Prepared for Parks Canada, Ontario Region, October 1996.

Gibson, Jonathon C., 1990. **“Assessing Cumulative Impacts of Land Use Development: Observations from the Vermont Experience”**. Prepared for the workshop on “Making decisions on Cumulative Impacts” of the Conservation Foundation, June 27-29 1990; co-sponsored by the Council on Environmental Quality, the Environmental Protection Agency and the National Science Foundation.

Gilpin, Alan, 1995. **“Environmental Impact Assessment: Cutting Edge for the Twenty-First Century”**. Cambridge University Press, Cambridge, U.K.

Ginger, Clare and Paul Mohai, 1993. **“The Role of Data in the EIS Process: Evidence**

from the BLM Wilderness Review". Environmental Impact Assessment Review 13: 109-139.

Glaholt, Randal D., 1994. "**Cumulative Effects Management in the Canadian Western Arctic**". pp. 265-274 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Glantz, Michael H., and Gordon McKay, 1986. "**Cumulative Atmospheric Impact Assessment**". pp. 131-140 in: CEARC and U.S. NRC, editors, 1986. "*Cumulative Environmental Effects: A Binational Perspective*" workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Gleick, James, 1987. "**Chaos - Making a New Science**". Penguin Books, New York.

Godschalk, David R., and Francis H. Parker, 1995. "**Carrying Capacity: A Key to Environmental Planning?**" pp. 498-509 in: Stein, Jay, editor, 1995. "*Classic Readings in Urban Planning: An Introduction*" McGraw-Hill, Inc., Toronto.

Gosselink, J., and L. Lee, 1989. "**Cumulative Impact Assessment in Bottomland Hardwood Forests.**" in: *Wetlands* 9 (Special issue): 93-174.

Hamilton, Andrew L., 1986. "**Commentary I**". pp. 45-47 in: CEARC and U.S. NRC, editors, 1986. "*Cumulative Environmental Effects: A Binational Perspective*" workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Harris, Larry D., 1988 "**The Nature of Cumulative Impacts on Biotic Diversity of Wetland Vertebrates**" in: *Environmental Management* 12(5): 675-693

Haskell, Benjamin D., Bryan G. Norton, and Robert Costanza, 1992. "**What is Ecosystem Health and Why Should We Worry About It?**" pp. 3-20 in: *Ecosystem Health: New Goals for Environmental Management*, edited by Robert Costanza, Bryan Norton and Benjamin Haskell. Island Press, Washington, D.C., 1992.

Hegmann, George, 1994. "**Cumulative Effects Assessment: Approaching Understanding and Implementation**". Prepared for Dr. Tony Yarranton, University of Calgary Environmental Research Centre, April 29 1994.

Hegmann, George, 1995. "**A Cumulative Effects Assessment of Proposed Projects in Kluane National Park Reserve, Yukon Territory**" Prepared for the Department of Canadian Heritage Kluane National Park Reserve, Haines Junction, Yukon, September

1995.

Hegmann, George L., and G.A. Yarranton, 1995. **Cumulative Effects and the Energy Resources Conservation Board's Review Process**. MacLeod Institute for Environmental Analysis Working Paper # 1, University of Calgary

Hems, David, 1996. **"Abandoning the Cult of the Artifact: Cultural Landscape Management on the Chilkoot Trail, Bennett - A Case Study"**. Cultural Resource Management Bulletin, Spring 1997, Department of Canadian Heritage.

Hems, David and Peter Nieuwhof, 1994. **"Bennett City: A Gold Rush Phenomenon"**. Canadian Heritage Research Bulletin, May 1994.

Hirsch, Allan, 1988. **"Regulatory Context for Cumulative Impact Research"** *in: Environmental Management* 12(5): 715-723

Horak, G.C., E.C. Vlachos, and E.W. Cline, 1983. **"Methodological Guidance for Assessing Cumulative Impacts on Fish and Wildlife"** Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Hubbard, Pamela M., 1988. **"Cumulative effects Assessment and Regional Planning in Southern Ontario"**. Prepared for the Canadian Environmental Assessment Research Council, May 31, 1988.

Irwin, Frances, and Barbara Rodes, 1992. **"Making Decisions on Cumulative Environmental Impacts. A Conceptual Framework"** Based on a June 1990 Workshop, World Wildlife Fund Washington, D.C.

IUCN/UNEP/WWF, 1980. **"World Conservation Strategy: Living Resource Conservation for Sustainable Development"**. International Union for Conservation of Nature and Natural Resources, United Nations Environment Programme and World Wildlife Fund, Gland, Switzerland.

IUCN/UNEP/WWF, 1991. **"Caring for the Earth. A Strategy for Sustainable Living"**. International Union for Conservation of Nature and Natural Resources, United Nations Environment Programme and World Wildlife Fund, Gland, Switzerland.

James, T.E., S.C. Ballard, and M.D. Devine, 1983. **"Regional Environmental Assessments for Policy Making and Research and Development Planning"**. Environmental Impact Assessment Review 4(1): 9-24.

Johnson, D.M., 1982. **"The use of Integrated Mapping Systems in Environmental Impact Assessment and Land Use Planning"**. pp. 353-357 *in: "Fifth International*

Symposium on Computer-Assisted Cartography and International Society for Photogrammetry and Remote Sensing Commission IV: Cartographic and Data Bank Application of Photogrammetry and Remote Sensing". Virginia, United States, August 22-28, 1982.

Kalff, Sarah, 1995. **"A Proposed Framework to Assess Cumulative Environmental Effects in Canadian National Parks"**. Masters Thesis, University of Dalhousie.

Kalff, Sarah, 1996. **"Cumulative Effects Assessment. Fortress of Louisbourg National Historic Site: A Case Study"**. Prepared for the Natural Resources Conservation Branch, April 1996.

Karr, J.R., 1992. **"Ecological Integrity: Protecting Earth's Life-Support Systems"**. pp. 223-238 *in*: Costanza, Robert, Bryan G. Norton, and Benjamin D. Haskell, editors, 1992. *"Ecosystem Health: New Goals For Environmental Management"*. Island Press, Washington, D.C.

Kay, James J., 1991a. **"The Concept of Ecological Integrity, Alternative Theories of Ecology and Implications for Decision-Support Indicators"**. pp. 23-49 *in*: Victor, Peter A., James J. Kay and H. Jack Ruitenbeek, 1991. *"Economic, Ecological and Decision Theories: Indicators of Ecologically Sustainable Development"*. Canadian Environmental Advisory Council.

Kay, James J., 1991b. **"A Nonequilibrium Thermodynamic Framework for Discussing Ecosystem Integrity"** *Environmental Management* 15(4): 483-495.

Keith, Todd, 1995. **"The Cumulative Effects of Development and Land Use at Gros Morne National Park, Newfoundland"**. Parks Canada Technical Reports in Ecosystem Science.

Keith, Todd, 1996. **"The Cumulative Effects of Development and Land Use at Prince Edward Island National Park"**. Parks Canada Technical Reports in Ecosystem Science.

Kingsley, Louise, 1997. **"A Guide to Environmental Assessments: Assessing Cumulative Effects"**. Prepared for the Natural Resources Branch, Parks Canada, 25 Eddy Street, Hull, Quebec, March 1997.

Klein, Heidi, 1993. **"Environmental Assessment in Land Use Planning"**. A major paper submitted to the Faculty of Environmental Studies, York University, Downsview, Ontario.

Lane, P.A., R.R. Wallace, R.L. Johnson, and D. Bernard, 1988. **"A Reference Guide to Cumulative Effects Assessment in Canada"**. Volume 1. Prepared for the Canadian

Environmental Research Council, October 1988.

Lawrence, David P., 1993. **“Quantitative Versus Qualitative Evaluation: A False Dichotomy?”** Environmental Impact Assessment Review 13: 3-11

Lawrence, David, 1994. **“Cumulative Effects Assessment at the Project Level”** Impact Assessment 12: 153-273.

Les Consultants Jacques Bérubé inc., 1996a **“Examen environnementale préalable, sentier de longue randonnée pédestre dans le parc national de la Mauricie”**. Parc national de la Mauricie, mars, 1996.

Les Consultants Jacques Bérubé inc., 1996b. **“Sentier de longue randonnée - Examen des impacts cumulatifs”**. Rapport final, le 12 décembre 1996.

Leung, Hok Lin, 1985. **“Towards a Subjective Approach to Policy Planning and Evaluation: Common-Sense Structured”**. Ronald P. Frye & Company, Winnipeg, Canada.

Locke, Harvey, 1994. **“Assessing the Public Interest: Environmental Impact Assessments, Cumulative Effects Assessments and Regulatory Decision-Making”**. pp. 291-302 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

MacNeill, Jim, Pieter Winsemius, and Taizo Yakushiji, 1991. **“Beyond Interdependence”**. Oxford University Press Inc., New York.

MacViro Consultants Inc., 1995. **“Cumulative Effects Monitoring Program for the Niagara Escarpment Area”**. Phase II final report, June 1995.

Manning, Edward W., and T. David Dougherty, 1995. **“Sustainable Tourism - Preserving the Golden Goose”** Cornell Hotel and Restaurant Administration Quarterly, April 1995:29 - 42.

Masse, Denis, 1993. **“The Moose and Wolf Issue in La Mauricie National Park”**. in: Parks Canada, 1993. *“The Ecological Integrity of La Mauricie National Park: A Week of Reflection”* workshop summary, February 22 to 26, 1993.

Masse, D., 1996. **“Ten Years of Monitoring of Common Loon Productivity in La Mauricie National Park, Québec”**. La Mauricie National Park, Resources Conservation Section. notes for document under preparation

May, Robert M., 1976. **"Simple Mathematical Models With Very Complicated Dynamics"**. *Nature* (June): 459-467.

McCold, Lance, and Jeremy Holman, 1995. **"Cumulative Impacts in Environmental Assessments: How Well Are They Considered?"**. *The Environmental Professional* 17:2-8.

McTaggart-Cowan, Ian, 1976. **"Cumulative Impact of the Development of the Mackenzie Estuary/Delta, N.W.T."**. in: *Mackenzie Delta: Priorities and Alternatives*. Conference Proceedings, Canadian Arctic Resources Committee, Ottawa, December 3-4 1976.

Milne-Ives, David, 1991. **"Chaotic Processes in Biology"**. *Crucible*, 22 (5): 12-15.

Ministerie van Volksgezondheid en Milieuhygiëne and Ministerie van Cultuur, Recreatie en Naatschappelijk Werk, 1981. **"Studies on Methodologies, Scoping and Guidelines. Conclusions and Recommendations"**. *Milieu - Effect - Rapportage 2*, Netherlands.

Morrison, Peter, 1994. **"Helping Practitioners: Decision Support Tools for CEA"**. Resource Futures International, Ottawa, Ontario. Paper presented to the 1994 conference of the International Association for Impact Assessment (IAIA), Quebec City, 1994.

Munn, R.E., 1986. **"Commentary 1"**. p. 125 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Munn, R.E. (ed.) 1994. **"Looking Ahead: The Inclusion of Long-Term "Global" Futures in Cumulative Environmental Assessments"**. Environmental Monograph No. 11. Institute for Environmental Studies, University of Toronto, Toronto, Ontario.

Munro, David A., 1986. **"Environmental Impact Assessment as an Element of Environmental Management"** pp. 25-30 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

NEPA, 1969. **"National Environmental Policy Act"** as ammended 42 U.S.C. parts 4321 et seq.

NTFEE, 1987. **"Report of the National Task Force on Environment and Economy"**. Report submitted to the Canadian Council of Resource and Environment Ministers,

September 24, 1987.

Natural Resources Branch, 1992. **"Natural Resources Management Process Manual"**. Canadian Heritage, Parks Canada.

NEB and CEAA, 1996. **"Express Pipeline Project"**. Report of the Joint Review Panel, May 1996. National Energy Board and Canadian Environmental Assessment Agency..

Norton, Bryan G., 1992. **"A New Paradigm for Environmental Management"**. pp. 23-41 in: Costanza et al., editors., 1992. *Ecosystem health: New Goals for Environmental Management*. Island Press, Washington, D.C.

Noss, Reed, 1995. **"Maintaining Ecological Diversity in Representative Reserve Networks"**. A World Wildlife Canada/World Wildlife Fund United States discussion paper, January, 1995.

Odum, William E., 1982. **"Environmental Degradation and the Tyranny of Small Decisions"**. *Bioscience* 32(9): 728-729.

Okrainetz, Glen, 1994. **"The Integration of Traditional Ecological Knowledge and Scientific Knowledge in the Assessment of Cumulative Effects: The Experience of the Hudson Bay Programme"**. pp. 149-158 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Orians, Gordon H., 1986. **"Cumulative Effects: Setting the Stage"**. Opening discussion in: *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

O'Riordan, J., 1986. **"Cumulative Assessment and the Freshwater Environment"**. pp. 55-66 in: *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Page, Robert, Suzanne Bayley, Douglas Cook, Jeffrey Green and J.R. Brent Ritchie, 1996a. **"Banff-Bow Valley at the Crossroads: Technical Report"**. Report of the Banff-Bow Valley Task Force to the Minister of Canadian Heritage, October 1996.

Page, Robert, Suzanne Bayley, Douglas Cook, Jeffrey Green and J.R. Brent Ritchie, 1996b. **"Banff-Bow Valley at the Crossroads: Summary Report"**. October 1996.

Parcs Canada, 1996. **"Énoncé d'intégrité écologique, Parc national de la Mauricie,**

1996" document préliminaire, service de la conservation des ressources naturelles, le 18 septembre 1996.

Parks Canada, 1993. **"The Ecological Integrity of La Mauricie National Park: A Week of Reflection"** workshop summary, February 22 to 26, 1993.

Parks Canada, 1994. **"State of the Parks 1993 Report"**. Department of Canadian Heritage. Minister of Supply and Services Canada.

Pelletier, Hervé. 1993. **"Description of the Natural Characteristics of La Mauricie National Park"**. *in*: Parks Canada, 1993. *"The Ecological Integrity of La Mauricie National Park: A Week of Reflection"* workshop summary, February 22 - 26 1993.

Peterson, E.B., Y.-H. Chan, N.M. Peterson, G.A. Constable, R.B. Caton, C.S. Davis, R.R. Wallace and G.A. Yarraton, 1987. **"Cumulative Effects Assessment in Canada: an Agenda for Action and Research"** A background paper prepared for the Canadian Environmental Assessment Research Council.

Postel, Sandra. 1992. **"Denial in the Decisive Decade"**. pp. 1-8 *in*: Brwon, Lester R., et al., *"State of the World 1992"*. A Worldwatch Institute Report on Progress Toward a Sustainable Society. WW. Norton and Company, New York.

Preston, Eric M., and Barbara L. Bedford, 1988. **"Evaluating Cumulative Effects on Wetland Functions: A Conceptual Overview and Generic Framework"** *in*: *Environmental Management* 12(5): 564-583.

Rapport, David J., 1992. **"What is Clinical Ecology?"** pp. 144-156 *in* :Costanza et al., editors., 1992. *Ecosystem Health: New Goals for Environmental Management*. Island Press, Washington, D.C.

Rapport, David J., 1995. **"Ecosystem Health: What's in a Name?"** Editorial for *Ecosystem Health* 1(1):1, March 1995.

Rapport, D.J., H.A Regier, and T.C Hutchinson, 1985. **"Ecosystem Behavior Under Stress"** *The American Naturalist* 125(5): 617-640.

Redclift, Michael, 1987. **"Sustainable Development: Exploring the Contradictions"** Routledge, Chapman and Hall, Inc., New York.

Rees, William E., 1988. **"Integrating Economy/Ecology: Toward a Role for Environmental Assessment in Sustainable Development"**. pp. 20-40 *in*: Gardner, J.E., W.E. Rees and P. Boothroyd, June 1988. *"The Role of Environmnet Assessment in Promoting Sustainable Development: Three Views"*. Discussion paper #13; UBC

Planning Papers, University of British Columbia, Vancouver, B.C.

Rennick, Paul. 1994. **"A Cumulative Effects Monitoring System for the Niagara Escarpment Plan Area"**. in *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Regier, H., 1986. **Freshwater - Scientific Perspective: Commentary II.** pp. 49-52 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Robinson, John, George Francis and Sally Learner, 1990. **"Defining a Sustainable Society"** in *Alternatives* 17(2): 36-46.

Roots, E.F., 1986. **"A Current Assessment of Cumulative Assessment."** pp. 149-160 in: CEARC and U.S. NRC, editors, 1986. *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Ross, William A., 1994. **"Assessing Cumulative Environmental Effects: Both Impossible and Essential"**. pp. 3-9 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Routhier, Yannick, 1993. **"The Management of Quebec Wildlife Reserves"** in: Parks Canada, 1993. *"The Ecological Integrity of La Mauricie National Park: A Week of Reflection"* workshop summary, February 22 - 26 1993.

R.S.C. 1992. **"The Canadian Environmental Assessment Act"**. Revised Statutes of Canada.

R.S.C. 1988. **"The National Parks Act"**. Revised Statutes of Canada.

Sadler, B., 1986. **"Cumulative Assessment and the Freshwater Environment: Commentary II"**. pp. 71-75 in: *"Cumulative Environmental Effects: A Binational Perspective"* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Sadler, Barry, 1996. **"Environmental Assessment in a Changing World: Evaluating**

the Practice to Improve Performance". Final report of the *International Study of the Effectiveness of Environmental Assessment*. Sponsored by the Canadian Environmental Assessment Agency and the International Association for Impact Assessment. Minister of Supply and Services Canada.

Sadler, Barry, and Peter Jacobs, 1990a. **"Conclusions and Recommendations on Further Directions for Research and Development"**. pp. 169-173 *in*: Sadler, B., and P. Jacobs, 1990. *Sustainable Development and Environmental Assessment: Perspectives on Planning for a Common Future*.

Sadler, Barry, and Peter Jacobs, 1990b. **"A Key To Tomorrow: On the Relationship of Environmental Assessment and Sustainable Development"**. pp 3-31 *in*: Sadler, B., and P. Jacobs, 1990. *Sustainable Development and Environmental Assessment: Perspectives on Planning for a Common Future*.

Sallenave, John D., editor, 1994. **"Towards the Assessment of Cumulative Impacts in Hudson Bay"**. A report from the Cumulative Impact Assessment Workshop held in Ottawa, Ontario, May 18 and 19th, 1993. The Hudson Bay Programme, 1994.

Savoie, André, and Stephen Woodley, 1993. **"The Mandate of the National Parks and the Stresses on Their Ecosystems"** *in*: Parks Canada, 1993. *"The Ecological Integrity of La Mauricie National Park: A Week of Reflection"* workshop summary, February 22 to 26, 1993.

Sebastiani, M., A. Sambrano, A. Villamizar and C. Villalba, 1989. **"Cumulative Impact and Sequential Geographic Analysis as Tools for land Use Planning, A Case Study: Laguna La Reina, Miranda State, Venezuela"**. *Journal of Environmental Management* 29: 237-248.

Shillington & Burns Consultants Inc., and Ecosystem Consulting Inc., 1996. **"Strategic Environmental Assessment: A Guide for Policy and Program Officers"**. Draft, March 1996. Prepared for the *Interdepartmental Committee on Policy and Program EA*, and the *Canadian Environmental Assessment Agency*.

Shoemaker, Darryl, 1994a. **"Cumulative Environmental Assessment in Ontario: Aggregate Resources"**. pp. 229-238 *in*: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Shoemaker, Daryl, 1994b. **"Cumulative Environmental Assessment"**. Department of Geography publication series no. 42, University of Waterloo, Waterloo, Ontario

Shopley, J.B., and R.F. Fuggle, 1984. **"A Comprehensive Review of Current**

Environmental Impact Assessment Methods and Techniques". Journal of Environmental Management 18: 25-47

Skidmore, Owings and Merrill, and Associates, 1981. **"Areawide Environmental Impact Assessment - A Guidebook"**. prepared for the U.S. Department of Housing and Urban Development, Office of Policy Development and Research, by Skidmore, Owings and Merrill, in association with Richard Grefé Associates, Bolt Beranek & Newman Inc., and Camp Dresser and McKee, Inc., June 19981.

Slocombe, D. Scott, 1994. **"Ecosystem Integrity as a Basis for Cumulative Effects Assessment"**. pp. 93-102 in: *Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists: edited by Alan J. Kennedy, 1994.

Sly, P.G., 1994. **"Human Impacts on the Hudson Bay Bioregion, It's Present State and Future Environmental Concerns."** Hudson Bay Program; Canadian Arctic Resources Committee (CARC), Environment Committee of Sanikiluaq, Rawson Academy of Aquatic Svience (RAAS).

Sonntag, N. C., R.R. Everitt, L.P. Rattie, D.L. Colnett, C.P. Wolf, J.C. Truett, A.H.J. Dorcey and C.S. Holling, 1987. **"Cumulative Effects Assessment: A Context for Further Research and Development"**. Canadian Environmental Research Council, Federal Environmental Assessment Review Office, Hull, Quebec.

Soulé, Michael E.. 1987 **"Introduction"** pp. 1-10 in: *Viable Populations for Conservation*, edited by Michael Soulé. Cambridge University Press, Cambridge.

Soulé, Michael E., and Daniel Simberloff, 1986. **"What does Genetics and Ecology Tell us about the Design of Nature Reserves?"**. Biol. Conservation 35: 19-40

Spaling, Harry H., 1993. **"A Conceptual Framework for the Analysis of Cumulative Environmental Change"** doctoral thesis presented to the Faculty of Graduate Studies of the University of Guelph, December 1993.

Spaling, Harry, and Barry Smit, 1993. **"Cumulative Environmental Change: Conceptual Frameworks, Evaluation Approaches, and Institutional Perspectives"**. Environmental Management 17(5): 587-600.

Sprague, L.G., and C.R. Sprague, 1976. **"Management Science?"** Interfaces 7: 57-62.

Stakhiv, Eugene Z., 1988. **"An Evaluation Paradigm for Cumulative Impact Analysis"** in: *Environmental Management* 12(5): 725-748

Stankey, George H., Stephen F. McCool, and Gerald L. Stokes, 1984. **"Limits of Acceptable Change: A New Framework for Managing the Bob Marshall Wilderness Complex"** Western Wildlands fall 1984, pp. 33-37.

Stevenson, W., 1994. **"Addressing Cumulative Environmental Effects in Environmental Assessment - An Indicators Approach"**. pp. 215-251 in: Munn, R.E. 1994. *"Looking Ahead: The Inclusion of Long-term "Global" Futures in Cumulative Environmental Assessments"*. Environmental Monograph No. 11. Institute for Environmental Studies, University of Toronto, Toronto, Ontario.

Stigliani, William M., Peter Doelman, Wim Salomons, Rainer Schulin, Gera R.B. Smidt, and Sjoerd E.A.T.M. Van der Zee, 1991. **"Chemical Time Bombs"** Environment 33(4): 5-30.

Stigliani, William, 1988. **"Changes in Valued "Capacities" of Soils and Sediments as Indicators of Non-Linear and Time-Delayed Environmental Effects"**. Environmental Assessment and Monitoring 10 (1988): 245-307.

Therrien, Bruno, 1993. **"The Management of Common Area 041-02"** in: Parks Canada, 1993. *"The Ecological Integrity of La Mauricie National Park: A Week of Reflection"* workshop summary, February 22 - 26 1993.

Ulanowicz, Robert E., 1992. **"Ecosystem Health and Trophic Flow Networks"**. pp. 190-206 in: Costanza et al., editors., 1992. *Ecosystem Health: New Goals for Environmental Management*. Island Press, Washington, D.C.

U.S. Department of Commerce, 1995. **Methodologies and Mechanisms for Management of Cumulative Coastal Environmental Impacts**. National Oceanic and Atmospheric Administration Coastal Ocean Office; NOAA Coastal Ocean Program. Decision Analysis Series No. 6.

WCED, 1987. **"Our Common Future"**. World Commission on Environment and Development, Oxford University Press, New York.

Walker, Donald A., and Marilyn D. Walker, 1991. **"History and Pattern of Disturbance in Alaskan Arctic Terrestrial Ecosystems: A Hierarchical Approach to Analysing Landscape Change"**. Journal of Applied Ecology 28: 244-276.

Weaver, J.L., R.E.F. Escano and D.S. Winn, 1987. **"A Framework for Assessing Cumulative Effects on Grizzly Bears"**. Trans. N. Amer. Wild. Nat Resour. Conf. 52: 365-376.

Weller, Milton W., 1988. **"Issues and Approaches in Assessing Cumulative Impacts"**

on Waterbird Habitat in Wetlands” *in: Environmental Management* 12(5): 695-701

Wight, Pamela, 1994. **“Limits of Acceptable Change: A Recreational Tourism Tool for Cumulative Effects Assessment”**. pp. 159-178 *in: Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

Woodley, Stephen, 1993a. **“Assessing and Monitoring Ecological Integrity in Parks and Protected Areas”** A thesis presented to the University of Waterloo in fulfillment of the thesis requirements for the degree of Doctor of Philosophy in Geography. Waterloo, Ontario, Canada, 1993.

Woodley, Stephen, 1993b. **“Monitoring and Measuring Ecosystem Integrity in Canadian National Parks”**. pp. 155-176 *in: Ecological Integrity and the management of Ecosystems*. Woodley, S., J. Kay and G. Francis, editors. Sponsored by Heritage Resource Centre, University of Waterloo, and Canadian Parks Service, Ottawa. St Lucie Press.

Young, James W.S., 1986. **“Commentary II”**. pp. 145-148 *in: CEARC and U.S. NRC, editors, 1986. “Cumulative Environmental Effects: A Binational Perspective”* workshop proceedings edited by the Canadian Environmental Assessment Research Council (CEARC) and the U.S. National Research Council Board on Basic Biology (U.S. NRC).

Zeimer, Robert R., 1994. **“Cumulative Effects Assessment Impact Thresholds: Myths and Realities”**. pp. 319-333 *in: Cumulative Effects Assessment in Canada: From Concept to Practice*. Papers from the Fifteenth Symposium Held by the Alberta Society of Professional Biologists; edited by Alan J. Kennedy, 1994.

IMAGE EVALUATION TEST TARGET (QA-3)

APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989

© 1993, Applied Image, Inc., All Rights Reserved