National Round Table on the Environment and the Economy

Table ronde nationale sur l'environnement et l'économie

Pathways to Sustainability:

Assessing Our Progress

Edited by Tony Hodge, Susan Holtz, Cameron Smith, and Kelly Hawke Baxter

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Canadian Cataloguing in Publication Data
Main entry under title:
Pathways to sustainability: assessing our progress
(National Round Table series on sustainable development; II)
includes bibliographical references
ISBN 1-895643-29-5

1. Sustainable development – Canada.
2. Environmental policy – Economic aspects – Canada. 3. Economic development – Environmental aspects – Canada. I. Hodge, Tony II. National Round Table on the Environment and the Economy (Canada)
III. Series HC120.E5P381995 333.7'2'0971
C95-900287-1

This book is printed on Environmental Choice paper containing over 50 percent recycled content including 10 percent post-consumer fibre, using vegetable inks. The coverboard also has recycled content and is finished with a water-based, wax-free varnish.

Book Design
Shoreline Communications

Printed and bound in Canada by
Lowe-Martin Printing

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National Round Table on the Environment and the Economy
Table ronde nationale sur l'environnement et l'économie
1 Nicholas St., Suite 1500, Ottawa, Ontario, Canada K1N 7B7

Series General Editor: Kelly Hawke Baxter, NRTEE
Tel: (613) 992-7189 Fax: (613) 992-7385

National Round Table Series on Sustainable Development

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The National Round Table on the Environment and the Economy is pleased to present this book as a further contribution to the greater understanding of the concept of sustainable development and its practical applications.

The views expressed herein are those of the authors and editors, and do not necessarily represent those of the National Round Table or its members.

Table of Contents

Foreword x

Preface xii

Acknowledgements xv

Introduction 1

Part I: Report to the Prime Minister 1

Part II: Colloquium on Sustainable Development Reporting 2

Part III: From Theory to Practice: Assessing Progress toward Sustainable Development in the Great Lakes Basin 2

Part IV: Anticipating the Future 3

Part I Toward Reporting Progress on Sustainable Development: Report to the Prime Minister 4

Executive Summary 5

In a Nutshell 5

The Need 6

The Benefits 6

Goals and Objectives 7

The Decision Makers 7

The Reporting Focus 7
The Indicators 7
Canada's Reporting Ability 8
The Motivation 8
The Underlying Value System 8
The Timing 9
The Cost 9
The Cost of Inaction 9
The Recommendations 10

Introduction 12
Key Definitions 14
A Brief Historical Note 14

Starting Points 17
Goals and Objectives 17
Reporting To, By, and For Whom? 17
Achieving Results 18
Reporting as Part of Decision Making 18
Fresh Perspective on Values 18

Blueprint for Reporting 21
The Reporting Focus 21
Ecosystem Indicators: Building on SOE Reporting 22
Interaction Indicators: Building on Economic and SOE Reporting 25
People Indicators (Human Well-Being): An Interdisciplinary Morass 29
Integration and Synthesis 32
Toward a Short List of Key Indicators 34

Decision Makers 37
Individuals and Households 37
Communities 39
Corporations and Corporate Groupings 44
The Federal Government 47

Epilogue 53

Endnotes 54

References 55

Part II Colloquium on Sustainable Development Reporting 58

Introduction 59

Approaches to Reporting on Ecosystem Health *by David Rapport* 60
The Concept of Ecosystem Health 60
Ecosystem Health as the Bottom Line 63
Economic Development and Environmental Change 64
Questions of Scale 66
Indicators of Ecologically Sustainable Development 67
Conclusion 71
References 71

Proceedings 73
Presentation by David Rapport 73
Response 75

Commonplaces and Heresies about the Human-Ecosystem Interface *by Ted Schrecker* 80
Introduction 80
Constant Wealth 81
Safe (or Sustainable?) Minimum Standards 84
Distributional Considerations 86
"Provocative Indicators" 89
Epilogue: Inside the Black Box 90
Endnotes 92

Proceedings 95
Presentation by Ted Schrecker 95
Response 96

Approaches to Reporting on Human Well-Being *by Susan Holtz* 104
Introduction 104
Disciplines, Definitions, and Discussions 105
Issues of Synthesis 111
References 112

Proceedings 113
Presentation by Susan Holtz 113
Response 113

Synthesis of Discussion *by Ted Schrecker* 118
Endnotes 125

Appendix – Colloquium Participants 126

Part III From Theory to Practice: Assessing Progress toward Sustainable Development in the Great Lakes Basin 128

1. Case Study Boundaries and Problem Definition 129
   1.1 Introduction 129
   1.2 Boundaries of the Great Lakes Basin Ecosystem 129
   1.3 Setting the Stage for Assessing Progress toward Sustainability 131

2. Historical Context: The Great Lakes Story 135
   2.1 Early Settlement 135
   2.2 Transportation 135
   2.3 Energy 136
   2.4 Manufacturing 137
   2.5 Population and Settlement Trends 137
   2.6 Hidden Costs 138
   2.7 Summary 145
   Endnotes 145

3. Systemic Assessment of Progress toward Sustainability in the Great Lakes Basin Ecosystem 146
   3.1 Strategic Element I – Ecosystem 146
   3.2 Assessment of Great Lakes Ecosystem Health and Integrity 153
   3.3 Strategic Element II – Human-Ecosystem Interaction 154
   3.4 Assessment of Human-Ecosystem Interaction in the Great Lakes Basin Ecosystem 162
   3.5 Strategic Element III – People 162
   3.6 Assessment of Human Well-Being in the Great Lakes Basin Ecosystem 164
   3.7 Strategic Element IV – Synthesis 165
   3.8 Assessment of Overall Progress toward Sustainability in the Great Lakes Basin Ecosystem 165
   3.9 Focus on Energy and Water 167
   Endnotes 167

4. Energy Production, Transportation, and Use in the Great Lakes Basin Ecosystem 169
   4.1 Introduction 169
   4.2 Two Approaches to Defining the Energy Problem 170
   4.3 Energy Efficiency, Quantity, and Quality 171
   4.4 The Starting Point: End-Use Analysis 173
   4.5 Balancing End-Use Requirements with Appropriate Secondary Forms and Primary Sources 175
   4.6 Proposed Indicators 175
   4.7 Application in the Great Lakes Ecosystem 176
   4.8 Assessment of Energy Production, Transportation, and Use in the Great Lakes Basin Ecosystem 182
   Endnotes 183

5. Surface and Groundwater in the Great Lakes Ecosystem 184
5.1 Introduction 184
5.2 Water and the Hydrologic Cycle 185
5.3 Proposed Indicators 187
5.4 Application in the Great Lakes Ecosystem 189
5.5 Assessment of the Water Subsystem in the Great Lakes Basin Ecosystem 197
Summary 200
Endnotes 200
6. Institutions and Implementation 201
7. Summary 203
7.1 The Great Lakes Basin Ecosystem is not on a Path toward Sustainability 203
7.2 Significant Limitations Remain in Knowledge and Analytic Technique 203
7.3 Detailed Subsystem Analysis is Powerful 204
7.4 The Overall Methodology has Strengths and Limitations 205
7.5 Implementation Remains Problematic 206
Appendix 1 – 1990 Activity Indicators for the Eight Great Lakes States and Ontario 207
Endnotes 217
References 217

Part IV Anticipating the Future 222
The Need for Anticipatory Thinking 224
What is the Good Life? 225
Judging According to the Weight of Evidence 227
Where Past and Future Meet 228

Foreword

When the World Commission on Environment and Development published its report *Our Common Future*, in 1987, Canada was the first country to recognize its significance in charting the future of mankind. A Task Force on the Environment and the Economy was established to develop a Canadian sustainable development program. The creation of the National Round Table on the Environment and the Economy was one of the Task Force's recommendations.

Since that time, many articles on the subject of sustainable development have been written, and a number of new definitions have been proposed. What is more important, however, is the change that has occurred in the business culture – a change that continues to go on today. Canadian society, including the business community, has made a major leap in better understanding the meaning of sustainable development and in implementing its principles, or perhaps its intentions. Canadian industry has recognized that to stay in business, it must make environment a part of business. Environmental considerations are now built into the economic decision-making process in many and perhaps most corporations. These corporations have also implemented effective environmental policies and management systems. Many of them are cutting-edge systems the rest of the world uses as models.

In the last five to ten years, industry, government and the public have made significant progress toward becoming a "sustainable development society". This progress could be compared with society's achievements over the last 30 years. Still, a great deal remains to be done. In order to accelerate this process of sustainability, a more concrete set of principles is required to translate the concept of sustainable

development into specific programs. There is a need for more transparency, more complete reporting, and other innovative ideas.

Noranda's commitment to sustainable development is clearly stated in our Environmental Policy, and we are genuinely and constantly searching for cutting-edge implementation management systems. Environmental/sustainable development reporting is one important element of such systems.

This book, *Pathways to Sustainability: Assessing Our Progress*, makes a significant contribution to establishing the content and format for sustainable development reporting and will very likely influence the future of environmental reporting by industry.

Dr. Frank Frantisak
Senior Vice-President, Environment
NORANDA INC.

Preface

Implicit in the title to this book, *Pathways to Sustainability: Assessing Our Progress*, is that it is we who are being assessed even though the results may be calibrated in terms of the health of the environment.

That perspective flows from a set of values that rejects division of the world into people and everything else and, instead, sees only an all-embracing ecosystem within which people, like coniferous forests or ocean mammals, are simply one component.

Once that view is accepted, it brings into focus the total dependence of people upon the health of all other subsystems. It strongly emphasizes that the well-being of people depends on the well-being of the ecosystem as a whole. It also emphasizes – and this is not as well recognized – that the health of the ecosystem is related to the well-being of people. And, most important of all, it recognizes that people are the dominant agent of change within the ecosystem.

Also implicit in the title is a confidence that measurements can, in fact, be made. That we need not wait for the perfect yardstick. That, given the wealth of information that already exists, we can at least come to preliminary assessments of where we stand in the struggle to maintain viable ecosystems. (A section from the doctoral thesis of Tony Hodge has been abbreviated and published here as a case study to illustrate how such assessments can be made; it appears as Part III of this volume.)

A Two-Track Research Program

The National Round Table on the Environment and the Economy is an agent of change. As such, it works to address immediate priorities in promoting sustainable development and also to determine what changes are needed over the long term in society's basic structures and values.

The National Round Table's Task Force on Sustainable Development Reporting refers to these responsibilities as Track 1 and Track 2. When it was constituted in the fall of 1991, it embarked on a program designed to address both.

As an immediate priority, it examined the ability of Canadians to monitor, assess,

and report on progress toward sustainable development. That resulted in a report from the National Round Table to the Prime Minister in December 1993 (Part I of this volume) that concluded:

> *Canadians do not have adequate information on which to base sound decisions concerning sustainable development, to set realistic sustainable development goals, or to measure progress against those goals.*

In other words, Canadians, individually and collectively, are not generating, assessing, and communicating the kind of data and information required to effectively monitor progress. The report offered 10 key suggestions for improving our monitoring ability.

However, even if the suggestions are implemented, there remain conceptual and theoretical complexities that will constrain progress on the reporting issue because some of the concepts evoked by the idea of sustainability have not been rigorously addressed. Consequently, the Task Force sought to address these long-term issues as a concurrent undertaking.

The heart of the problem lies in the difficulty of defining an underlying acceptable set of indicators that capture the values implied by sustainable development, and in systematically describing the systems being monitored. This is a tall order for there are many operating value sets and many ways of characterizing the world in which we live. But without resolving these conceptual issues, the inadequacy of current indicators will remain.

The set of values proposed and discussed in this book is defined as "a parallel concern and respect for the ecosystem and the people within – not one or the other, not one more than the other, but both together."

A Key Contribution

At the time the Task Force was beginning its work, the issues were already being addressed in an interdisciplinary doctoral study at the School of Urban Planning at McGill University. That study was approaching the issues from both a Canadian and an international perspective. Its work at the international level was supported by the International Development Research Centre (IDRC).

Early in the Task Force's work, the McGill study made two significant contributions. First, it pinpointed the need to shift from a choice of specific monitoring measures to the design of a systematic assessment process. It clarified that, without such an approach, any choice of indicators would continue to be ad hoc, reactive to current issues, and unlikely to progress beyond immediate concerns.

Secondly, drawing on an extensive review of values related to the concepts of sustainability and sustainable development, together with a review of some 30 theoretical treatments of human-ecosystem relationships, and several hundred state-of-environment reports from around the world, it developed a four-part categorization of data and information. That categorization, first articulated in a report to the IDRC[1], formed the basis of the National Round Table's report to the Prime Minister.

It was to elicit responses to this approach that the Task Force organized the 1993 Colloquium on Sustainable Development Reporting (see Part II of this volume). The colloquium surpassed our expectations in terms of both the quality and the passion of the debate. What came as a surprise was that, in the field of human well-being, the weakness in monitoring, assessing, and reporting was so pronounced. As a result,

a second colloquium was convened in early 1995 to address this issue. (The results of the second colloquium will be published later in 1995.)

A Rapidly Evolving Field of Enquiry

In the period since our Task Force began its work, Canada's political landscape and attendant policy priorities have shifted significantly. Further, a number of the recommendations included in our report to the Prime Minister have been addressed by the federal government.

The government's announcement of its intent to create a Commissioner of Environment and Sustainable Development within the office of the Auditor General is a significant step forward. Equally important, the creation of departmental and government-wide strategies for sustainable development will provide the goals and objectives that will serve as the Commissioner's assessment framework.

These initiatives and the many others that are unfolding across the country at the provincial, territorial, and community level, are now driving the process of bringing the ideas of sustainability from theory to practice. As the experience of practical application grows, the nature and sophistication of the reporting or feedback component will continue to evolve rapidly.

In the course of our work we have been continuously reminded of the limits of our knowledge and understanding. Our hope with this volume is to contribute to expanding the awareness of our links with each other and with the ecosystem of which we are part.

1. R.A. (Tony) Hodge, "Reporting on Sustainable and Equitable Development," Paper prepared for the Corporate Affairs and Initiatives Division, International Development Research Centre, Ottawa, 1993.

Acknowledgements

In the process of developing the various initiatives summarized in this book, we were aided by a number of individuals and organizations to whom we owe a debt of gratitude.

Preparation of the Report to the Prime Minister (Part I) began with three commissioned studies. Trevor Hancock led the examination related to individual, household, and community decision making. He was assisted in this task by Sylvia Robinson and Shannon Turner of the October Group (Victoria). David Nitkin and David Powell of EthicScan Canada completed the review of corporate reporting. Francois Bregha, John Moffet and Vic Nishi of Resource Futures International did so for government reporting.

David Runnalls and John Cox, then of the Institute for Research on Public Policy, prepared an early synthesis on which our final report was based. In addition to the above individuals, we were assisted in a workshop review of the background papers by Anne Kerr (Environment Canada), Steve Pomeroy (Canadian Mortgage and Housing Corporation), Ted Schrecker (Westminster Institute for Ethics and Human Values, University of Western Ontario), Susan Sheehan (Department of Supply and Services), and Carl Sonnen (Infometrica). Tony Cassils provided a number of insights, particularly regarding the financial services industry. From the NRTEE secretariat, Dominica Babicki undertook specialized statistical research.

Three times, drafts of the Report to the Prime Minister were scrutinized by the full National Round Table in plenary session. The resulting debate served to greatly enrich the final product.

In a parallel initiative, the International Development Research Centre (IDRC) was exploring development of a system of reporting on sustainable development that would be relevant to both developing and developed parts of the world. The interplay between the NRTEE project and the IDRC project enriched both.

We owe a special debt of gratitude to Philippe Clément for his work in preparation of the Report to the Prime Minister. He provided ongoing advice and coordination of our Task Force and its predecessor since the inception of the National Round Table to the spring of 1994. His steady counsel, continuing efforts, and insights served as a cohesive force that we could not have done without.

The Colloquium on Sustainable Development Reporting (Part II) was hosted jointly by the National Round Table and the Westminster Institute for Ethics and Human Values, University of Western Ontario. Ted Schrecker, Associate Director (Environmental Ethics) and Jean Dalgleish (Assistant Director and Projects Manager) carried the brunt of organizational responsibilities. The success of the colloquium was largely due to their efforts. Also we are grateful for the efforts of Ted Schrecker and David Rapport (University of Ottawa) who, along with Susan Holtz, prepared and delivered papers at the colloquium which are published along with the proceedings in Part II.

Development of the Case Study (Part III) took place as part of an interdisciplinary Ph.D. research project at the School of Urban Planning, Faculty of Engineering, McGill University. Financial support for the Ph.D. project was provided by the Social Sciences and Humanities Research Council of Canada and the Eco–Research Program of the Tri–Council Secretariat. Professor Ron Rice (Civil Engineering/Planning) supervised the work. His quiet advice and constant insight are gratefully acknowledged.

Thanks also to Jane Whitney for painstakingly copy editing the entire manuscript and to Jennifer Jarvis for a thorough proof read. Shoreline Communications designed the cover and interior layout and patiently accepted numerous rounds of authors' alterations as the manuscript evolved into its current form.

We are especially grateful for the financial support provided by Noranda Inc. to assist with the production and distribution of this book to a wide audience.

Many other individuals were involved as the elements of this book evolved through various stages. Through they remain unnamed, we are greatly appreciative of their input.

Tony Hodge
Susan Holtz
Cameron Smith
Kelly Hawke Baxter

Introduction

How can progress toward sustainability be measured and assessed? In simplified terms, that was the question posed by the National Round Table on the Environment and the Economy in 1991 when it established a Task Force on Sustainable Development Reporting.

Pathways to Sustainability: Assessing Our Progress is an answer to the question. It is a record of thought, and it is presented here in a simple format that in four distinct parts proposes, discusses, demonstrates, and anticipates.

The first part (proposing) contains the National Round Table's Report to the Prime Minister entitled *Toward Reporting Progress on Sustainable Development in Canada.* It was presented in December 1993.

The second part (discussing) is the record of a colloquium sponsored by the National Round Table and held in London, Ontario, on November 25 and 26, 1993.

The third part (demonstrating) is an excerpt from the Ph.D. dissertation of Tony Hodge, a member of the National Round Table and chair of the Task Force on Sustainable Development Reporting. The excerpt assesses progress toward sustainability in the Great Lakes basin ecosystem. The thesis was completed over a six-year period beginning in 1989.

The fourth part (anticipating) is a look ahead by the Task Force that identifies challenges that should be addressed.

Part I: Report to the Prime Minister

A framework for measuring and assessing progress is described in a section of the report to the Prime Minister called "Blueprint for Reporting." The "blueprint" proposes four indicator domains, or areas of diagnosis, as cornerstones for the framework. They were previously defined in a research paper prepared by Tony Hodge for the International Development Research Centre (IDRC) and deal with[1]:

Domain I	Ecosystem integrity
Domain II	Interaction (between people and the ecosystem)
Domain III	Human well-being
Domain IV	Synthesis of the first three domains

As the report to the Prime Minister says, "Framing the indicator domains in this way achieves two things: it recognizes that people are part of the ecosystem; and it stresses that what has to be managed is human activity. This last is extremely important because of the long-held view that people can manage the environment. Such a view, because it offers a false premise, can only lead to misplaced policies...Society can only manage the activities of people...and people, in turn, interact with the environment." It is a distinction that helps to emphasize not only that people are responsible for their actions but also that, through their choices, they can make a difference.

Part II: Colloquium on Sustainable Development Reporting

The Colloquium on Sustainable Development Reporting was convened to test the ideas contained in the report to the Prime Minister and to invite suggestions for improvements. Prior to the colloquium, participants received three papers commissioned for the event, each focussing on one of the first three indicator domains, as well as a copy of the IDRC research paper. (The report to the Prime Minister was not ready for publication at the time.)

Proceedings were organized around three firm convictions. First, that as a society we should be establishing benchmarks in all activities and within all ecosystems by which we can measure progress toward sustainability. Second, that the concept of sustainability should extend beyond economic and environmental well-being to include human well-being. Third, that we do not need to wait for better systems of measurement or greater scientific certainty — we can make judgments based on the existing weight of evidence, just as the courts of common law have for 700 years.

Among the 20 participants attending were professors, consultants, economists, government officials, environmentalists, and officials of international agencies. No attempt was made to reach consensus. No requests for action plans were made. Debate was conducted with transilient enthusiasm and the results were extremely helpful.

The papers commissioned were:

Domain I: "Approaches to Reporting on Ecosystem Health," by David Rapport of the Department of Biology, University of Ottawa;

Domain II: "Commonplaces and Heresies about the Human-Ecosystem Interface," by Ted Schrecker of the Westminster Institute for Ethics and Human Values; and

Domain III: "Approaches to Reporting on Human Well-Being," by Susan Holtz, a founding member of the National Round Table.

Each paper is published in its entirety and is followed by a summary of the author's presentation, a synopsis of response (serving somewhat the same purpose as an abstract in an academic journal), a formal critique of the paper by a participant (this was not available for the third paper), and reports of commentary and discussion.

Part II concludes with a "Synthesis of Discussion" prepared by Ted Schrecker.

Part III: From Theory to Practice: Assessing Progress toward Sustainable Development in the Great Lakes Basin

An excerpt from Tony Hodge's thesis is included here as a case study because it demonstrates how the framework for reporting, proposed in the report to the Prime Minister and debated at the colloquium,

actually works when applied to an ecosystem. It shows, step by step, how assessments can be made based on methodical sorting of available information and the application of informed judgment.

The case study is the work and opinion of one person. It was not prepared under the authority of any organization and does not purport to be a definitive assessment. Nevertheless it illustrates what a benchmark can look like. And it is an example of how judgments can be made on the weight of evidence.

Part IV: Anticipating the Future

One of the more useful functions of the colloquium was to identify key challenges that need to be addressed. Chief among them are learning to assess human well-being, developing skills in anticipatory thinking, and exploring how to gauge "the good life."

If there is one overriding conclusion that is reaffirmed by all that appears between these covers, it is that judgments can and should be made on the weight of evidence. It will take time to refine methodologies, but in the interim we will be learning how to deal with the future.

1. R.A. (Tony) Hodge, "Reporting on Sustainable and Equitable Development," Paper prepared for the Corporate Affairs and Initiatives Division, International Development Research Centre, Ottawa, 1993.

Part I

Toward Reporting Progress on Sustainable Development

Report to the Prime Minister

Toward Reporting Progress on Sustainable Development was first published by the National Round Table on the Environment and the Economy in December 1993. This version contains minor editorial revisions.

Executive Summary

In a Nutshell

Good decisions require good information. This report suggests that Canadians do not have adequate information on which to base sound decisions concerning sustainable development, to set realistic sustainable development goals, or to measure progress toward those goals. It recommends strengthening the federal government's role in facilitating more effective reporting of information, and in so doing, it focusses on four major decision-making groups: households, communities, for-profit corporations, and governments.

As a first step, it recommends that the federal government entrench a commitment to sustainable development and to sustainable development reporting in the mandates of its departments, agencies, and crown corporations. Such a policy should make individual departments clearly responsible and accountable for ensuring that their policies, programs, and budgets support only those activities that contribute to sustainable development.

Secondly, it recommends establishing a capability for annually assessing and reporting on progress toward sustainable development within the federal government as a corporate entity. Careful consideration will have to be given to choosing the exact mechanism. What is most important is that the responsibility centre be independent, be able to link effectively to all elements of the federal system, and be able to work harmoniously with all those elements. It should not, therefore, be embedded within any existing department.

Thirdly, it says discussions should be initiated with provincial and territorial governments, and other stakeholders, with the aim of establishing a mechanism for assessing and reporting, at five-year intervals, on progress toward sustainable development for the nation as a whole.

An additional seven recommendations deal with federal procurement policies, nurturing the setting of corporate and consumer reporting standards at levels that compare favourably with the highest in the world, establishing joint departmental responsibilities for the Environmental Choice Program

and the National Pollutant Release Inventory, addressing the reporting needs of community decision makers, establishing sustainable development codes of practice, and linking Statistics Canada to a program to enhance awareness and knowledge of sustainable development that is being undertaken in partnership by the National Round Table on the Environment and the Economy and ParticipACTION.

The Need

After five years of discussing the ideas of the Brundtland Commission, we still cannot answer basic questions. Is Canada progressing toward sustainable development? If so, how fast – and is it fast enough? If not, why not?

Without the means of measurement, without relevant information, progress cannot be charted, goals cannot be set, existing situations cannot be assessed, plans cannot be laid – cannot, that is, with any degree of composure or assurance.

To take an example that underlines the importance of reporting: If Statistics Canada did not provide extensive data on the performance of the Canadian economy, could we adequately chart progress, set goals, assess situations and lay plans for businesses, governments, institutions, communities, and households with any degree of composure or assurance?

Of course not. Yet sustainable development is based on the concept of integrating the economy and the environment. That means changing the way we make decisions on *everything* – and there is no way that can be done without a tracking system for sustainable development that links and is integrated with what Statistics Canada currently supplies for the economy alone.

In short, Canada needs to develop a system of measuring and reporting sustainable development performance in a meaningful and credible way.

The Benefits

More than in anything else, the power of sustainable development lies in its bridging capability – its ability to facilitate integration, synthesis, and collaborative approaches to problem solving. It ensures that decisions and strategic directions are based on:

- encouraging activities that enhance social, cultural, economic, and environmental conditions in both the short and the long term;
- minimizing environmental stress and related problems that impose severe costs on society by engaging in anticipatory management and preventive action; and
- saving financial resources by eliminating unwise subsidies to unsustainable activities.

A serious national commitment to reporting on sustainable development will force clarification by linking cause and effect more clearly. It will translate the concept of sustainable development into practical terms for use by decision makers and make it much more probable that strategic directions will be chosen that conform with sustainable development.

Most importantly, the very act of making a commitment to monitor, assess, and report progress will entrench the concept of sustainable development in practice and thereby accelerate changes to the framework within which decisions are made.

The result will be an enriched quality of life, a safeguarding of ecosystem integrity, and an enhanced competitive position internationally that, at the same time, reduces the gap that currently exists between developed and developing regions within Canada and around the world.

Goals and Objectives

The overarching goal of reporting on sustainable development is to improve the way we make decisions, that is, to support informed and responsible decision making by:

- communicating key signals to targeted decision makers, especially by delivering early-warning signals that indicate the need for policy changes, shifts in behaviour, or institutional adjustments;
- ensuring accountability;
- encouraging initiative by giving credit where credit is due; and
- identifying knowledge gaps and providing rationales for giving priority to filling the gaps.

The Decision Makers

In western, market-driven democracies, the following four decision-making groups are likely to be the most significant:

- individuals and households;
- corporations and corporate groupings;
- communities and settlements; and
- regional, provincial, and national governments.

The Reporting Focus

Reporting on sustainable development must measure performance in economic, environmental, social, and cultural terms. And it must do so within every sphere of activity that it addresses. Since there will be a host of activities upon which attention could be directed, a blueprint that shows how a reporting system would work will be needed in order to determine what should be reported.

This report suggests that there are four main areas of diagnosis that should be considered in assessing progress toward sustainable development – we call them indicator domains. They are the touchstones against which progress toward sustainable development is best measured and should be the focus of reporting. They are:

I Ecosystem
An assessment of the integrity, health, or well-being of the ecosystem;

II Interaction
An assessment of the interaction between people and the ecosystem: how and to what extent human activities contribute to the provision of basic needs and the quality of life; how these actions stress, or contribute to restoring, the ecosystem; and how successful we have been at meeting the goals and objectives of policies, regulations, and legislation;

III People
An assessment of the well-being of people in the broadest sense (individuals, communities, corporations, regions, provinces, nations, and other decision-making groups); the assessment should range across physical, social, cultural, and economic attributes; and

IV Synthesis
An assessment of the whole, looking at key linkages across the above three components.

The Indicators

Each indicator domain spans a wide range of disciplines, and associated with each domain are a number of indicators that already are being reported. Most of these indicators gained prominence simply because they existed and not because they were picked as part of a coherent reporting system. They fill a need and have emerged, rightfully so, because of their specific usefulness. However,

they developed in isolation from insights in other disciplines and in the absence of co-ordinating links.

These indicators inevitably will provide some of the building blocks for a "family" of sustainable development indicators. On their own, however, they are inadequate. To appreciate this inadequacy, it is necessary only to return to the example of the economic reporting system in Canada. Statistics Canada lists close to 1,000 industry classes and each class has a number of indicators to report. Obviously, nothing remotely approaching that scale can be expected immediately for reporting on sustainable development.

Nevertheless, given the integrative perspective of sustainable development, new insights will lead to new and more powerful indicators. It may be possible eventually to identify a short list of key indicators of sustainability. However, that process will take time.

Canada's Reporting Ability

At this time, Canada cannot offer a definitive assessment of progress toward sustainable development. We know in general terms that while some elements of society are adjusting, many are not. We also can recognize a significant shift in societal values that provides a new context for decision making, a context in which parallel concern for people and the environment broadens the narrow focus on purely economic matters that has dominated the way we have assessed progress throughout this century.

Only a small, leading group of innovative Canadians, mainly at the grass-roots level, has made much progress in grasping the essence of sustainable development. Our most exciting innovations have come from them. However, our current information systems are aimed at the needs of provincial and federal governments and large corporations, and are not well tailored to support decision making by individuals, communities, and small businesses. Consequently, it is essential that we nourish bottom-up, grass-roots development.

Our review has revealed a number of encouraging developments. The 1991 *State of Canada's Environment* (Environment Canada) along with the parallel publication of *Human Activity and the Environment* (Statistics Canada) are being recognized internationally as setting new standards for reporting. Ongoing work aimed at integrating environmental concerns in macroeconomic analysis through satellite accounts to the System of National Accounts is encouraging. Also noteworthy are initiatives taken by a number of federal departments, provincial governments, and major corporations aimed at choosing new strategic directions in line with the ideas of sustainable development. However, for most people, concern and action remain limited to after-the-fact "environmental protection" at best. We are far from entrenching an anticipatory and preventive stance. Our practice and our ability lag well behind our intentions and even farther behind our rhetoric.

The Motivation

There are three strong motivations for making sustainable development a reality:

- enlightened self-interest;
- the public's right to know; and
- the growing value set that entrenches care and respect for both people and the enveloping ecosystem.

The Underlying Value System

The foundation of the work to develop a system for reporting on sustainable development is a value set based on a parallel concern and respect for people and for the enveloping

ecosystem – not one or the other, not one more than the other, but both together.

Sustainable development brings a new perspective that carries with it new responsibilities and an expanded value base that must be merged with the old. Developing a system of reporting on sustainable development offers the opportunity to nourish this shift.

The Timing

There is an urgent need for action. Canada, like most countries, is in a remarkable period of transition. Restructuring at a global scale is unprecedented. Decisions are being made today that will have significant, long-term impacts – economically, socially, culturally, and most importantly, ecologically. We have a window of opportunity to establish the kind of system needed to track progress, ensure rapid response to needed change, and entrench an anticipatory capability to prevent problems before they occur. Only through such a system will we be able to maximize learning as we go and, as a result, minimize wastage of society's limited human, financial, and natural resources.

The Cost

Few would have guessed 50 years ago that our Standard Industrial Classification would grow to accommodate the tracking of economic and social signals from close to 1,000 industry classes in Canada. By the mid-1980s, the federal government was spending three quarters of a billion dollars and employing more than 10,000 people to collect basic information about Canada, its people, its economy, and the ecosystem. In addition, the provinces spend $125 million to $150 million a year. We are unaware of a comparable figure for private-sector corporations, but it probably is as large as that for the federal government.

The proposed approach to reporting on sustainable development is not aimed at re-creating or replacing existing elements of Canada's information system. Rather, it urges that we build on what is there now. It is best thought of as creating a small, but critical, missing link.

We have reviewed costs related to several existing federal initiatives and have concluded that an annual commitment of $3 million in support of 20 full-time employees is probably the appropriate level of effort needed to establish a capability for reporting on sustainable development. The money and the people should be found within existing allocations for the gathering, processing, and assessing of data and information.

The Cost of Inaction

Over the past 25 years, Canada has accumulated a huge debt. Part of it is expressed in terms of the public accounts deficit. An equally important part is hidden. It is the cost we are going to have to pay to deal with ecological degradation.

For example, it is estimated that tens of billions of dollars will be required to restore ecosystem integrity on the Great Lakes-St. Lawrence system alone. And the longer we delay, the higher will be the cost.

Both of these debt components pass on costs to our children and threaten to reduce the possibility of them enjoying the same quality of life as has been ours. They represent the growing cost of inaction. Recognition of this simple fact was the starting point of the Brundtland Commission, as it is ours.

Part of the reason that we find ourselves with such debts is that we have a totally inadequate system for monitoring and assessing current conditions, interpreting past decisions, and anticipating longer-term implications.

The Recommendations

We need to shift the pens and upgrade the quality of the signals that feed decision making. This is the task to be addressed by a system of reporting on sustainable development.

Consequently, we offer the following recommendations. They are grouped by departmental responsibility.

We recommend that the Government of Canada:

1. ***Develop a policy statement that entrenches a government-wide commitment to sustainable development in the mandates and reporting responsibilities of federal departments, agencies, and crown corporations.***

It is essential that this policy make individual departments responsible and accountable for ensuring that their policies, programs, and budgets encourage and support activities that are economically and ecologically sustainable, both in the short and longer terms.

2. ***Establish a capability for:***

a. ***assessing and reporting annually on progress toward sustainable development within the federal government as a corporate entity; and***

b. ***reviewing the environmental implications of actions taken as a result of existing statutes, policies, programs, and regulations – as promised in*** **Canada's Green Plan.**

Exactly what shape this office should take and where it should be located – within, or at arm's length to, the federal government – requires further assessment. What is most important is that it be clearly assigned this responsibility and given authority for discharging it. Further, the office must be independent and able to link effectively to, and work with, all parts of the federal system. It cannot, therefore, be embedded within any existing department.

3. ***Initiate discussions with provincial and territorial governments, and other stakeholders aimed at:***

a. ***designing and establishing a capability for assessing and reporting every five years on progress toward sustainable development for Canada as a whole; and***

b. ***providing an assessment every five years of domestic legislation and regulations (provincial, interprovincial, and federal), as well as international treaties and conventions, that are relevant to sustainable development and that impact on Canada's trade position, economic prosperity, and ecosystem integrity.***

4. ***Restructure the Environmental Choice Program to be a joint responsibility of Environment Canada and Industry Canada.***

In follow-up, every effort should be made to expand the program to cover a broader range of products and to upgrade program marketing to ensure more effective outreach.

5. ***Identify a responsibility centre and provide it with the mandate to initiate discussions with provincial and municipal partners (including the national and provincial associations of municipalities) aimed at:***

a. ***identifying and prioritizing specific data and information needs of community decision makers related to sustainable development; and***

b. exploring the feasibility of establishing a national clearinghouse and other ways by which these needs might best be met.

6. Make a commitment to having corporate and consumer standards set, in particular for reporting, that will compare favourably to the highest in the world.

Overall, we conclude that significant gaps exist between what ideally should be reported, what currently is practical to report, and what is being reported. Closing these gaps will take time. In the meantime, corporate sustainable development reporting should be nurtured but not regulated; encouraged but not standardized; reinforced but not necessarily legislated.

7. Make Statistics Canada jointly responsible with Environment Canada for development and implementation of the National Pollutant Release Inventory.

Management of the program should be aimed at collecting accurate and timely data that keeps to a minimum duplication with other efforts to gather data and information.

8. Take the necessary steps to encourage all corporate entities (including for-profit businesses, not-for-profit voluntary organizations, professional associations, co-operatives, hospitals, unions, universities, colleges, and community colleges) to:

a. develop sustainable development codes of practice; and

b. implement practical reporting systems to facilitate monitoring and assessment of progress over time.

9. We recommend that Statistics Canada:

a. systematically gather and periodically report data and information concerning individuals and households that is related to the state and progress of sustainable development; and, to that end

b. join with the National Round Table and ParticipACTION in their social marketing initiative to jointly:

- *design, develop, and launch a national sustainable development home survey and report-back program; and*
- *motivate people to participate.*

The program will provide an opportunity for Statistics Canada to develop and implement an ongoing individual and household database with information from all parts of Canada. It should aim at enabling individuals and households to monitor, assess, and report their activities and to compare them to local, regional, provincial, and national averages.

We recommend that the Treasury Board:

10. re-assign priority to efforts that will lead to the development and implementation of a government-wide procurement strategy and related tracking system that:

a. reflects the principles of sustainable development;

b. provides the Cabinet, Parliament, and the public with a three- to five-year perspective on government procurement plans; and

c. includes a reporting system that effectively compares actions with intentions.

Introduction

After five years of discussing the ideas of the Brundtland Commission, is Canada progressing toward sustainable development? If so, how fast are we progressing? Is it fast enough? If not, what are the priority concerns? These are the questions that motivated this report.

At this time we cannot provide definitive answers. We know in general terms that while some elements of society are adjusting, many are not. And we are aware of the dark consequences of a failure to adjust.

We can recognize a significant shift in societal values that offers a new context for decision making but – and this is the crux of our present dilemma – we do not have the essential tool to make those decisions. The tool we need is information.

The reason we do not have it is that we do not have a reporting system that can monitor progress toward sustainable development. We do not have a system that supplies decision makers with the signals they need in order to make realistic choices.

In making decisions that strive toward sustainable development, the difficulty encountered is that there are many, many variables that need to be considered. The entire concept of sustainable development is structured around the proposition that every decision has ripple effects and, just as when we throw several pebbles into a pool, when the ripples intersect they produce still different ripples.

In other words, sustainable development deals with interrelationships and linkages. It means looking at decisions in a holistic way where there is a parallel care and respect for people and for the enveloping ecosystem of which everyone is a part.

But if we do not report the ripples – and their intersections – how do we know the effect of decisions? How do we have any assurance that we will be basing decisions on sound analysis? How can we judge the consequences of those decisions? And how do we know if we are aiding or hindering progress toward sustainable development?

Consequently, if decision makers are to implement sustainable development policies, and if the public is to gain trust in those policies, Canada must develop some system of measuring and reporting performance in a meaningful way.

Part of the process of developing such a system will be to focus on underlying values because they will determine what should be measured. For instance, the traditional approach to biodiversity has been to ask, "How do we pinpoint the worth of the ecosystem?" The assumption is that in the order of competing priorities, it has its own private position.

It has led to arguments that biodiversity is worth preserving because research into tropical plants provides us with new medicines. Or because it supports a multibillion-dollar tourism industry. Or because biodiversity has a value in its own right that ought to be protected.

None of these arguments offers a satisfactory approach. But what if the question is changed. What if we take a more holistic approach and ask: "What role does biodiversity have in determining the quality of life?" The question reflects a shift in emphasis that brings into sharp focus a concern for the well-being of people and the integrity of the ecosystem, and removes us from the murky realm of trying to place an independent evaluation on the ecosystem.

The shift follows naturally from the concept of parallel care and respect for people and the enveloping ecosystem that is at the heart of sustainable development. Once it is made, it brings into light responsibilities that previously lay hidden. And it heralds the need to adjust value systems. Developing a national reporting capability will aid greatly in that adjustment.

The National Round Table on the Environment and the Economy recognizes that it has a special responsibility regarding reporting on sustainable development in Canada. In the short term, its goal is to encourage initial assessments of progress toward sustainable development within the context of current conceptual and resource limitations. Over the long term, its role will be to act as a catalyst in the eventual development of a comprehensive reporting system.

Like other countries, Canada is in a remarkable period of transition. The National Round Table thinks that, in this transition, sustainable development has a unique contribution to make by identifying strategic directions that will:

- encourage activities that enhance social, cultural, economic, and environmental conditions in both the short and the long term;
- minimize environmental stress and related costs through anticipatory management and preventive action; and
- save financial resources by reducing unwise subsidies to unsustainable activities.

The result will be an enriched quality of life, the safeguarding of ecosystem integrity, and an enhanced competitive position internationally that, at the same time, reduces the gap that currently exists between developed and developing regions within Canada and around the world.

However, the contribution that can be made by sustainable development will be foreshortened if a system of reporting is not established as soon as possible. The reason is that progress toward sustainable development is dependent, in large part, on reliable reporting. Not only will such reporting track

progress, ensure rapid response to needed change, and entrench an anticipatory capability to prevent problems before they occur, it also will be a catalyst for social change in its own right by improving public awareness. Only with such a system will we be able to maximize learning as we go and, as a result, minimize wastage of society's limited human, financial, and natural resources.

There is a window of opportunity, now, for doing all this. But restructuring on a global scale is unprecedented. Decisions are being made today that will have significant long-term impacts – economically, socially, culturally, and, most importantly, ecologically. The longer we wait, the more extensive will be the restructuring undertaken without the benefit of insights that sustainable development can offer.

Key Definitions

The concept of sustainability is best defined as:

> *the persistence over an apparently indefinite future of certain necessary and desired characteristics of both the ecosystem and the human subsystem within.*[1]

Sustainability is a normative attribute of something, such as the ecosystem, biodiversity, development, communities, the nation, the family farm, or society.

Sustainability of development – or sustainable development[2] – focuses on human activities and on related development that:

> *meet the needs of the present without compromising the ability of future generations to meet their own needs.*[3]

This definition is especially appropriate because it focusses on managing human activity and abandons all pretence of trying to "manage" the environment. Policies, decisions, and regulations cannot "manage" the environment; all they can do is regulate human activity as it affects the environment.

The word "development" is used here in the sense of:

> *to realize the potentialities of, to bring to a better state.*[4]

When it is used in reference to sustainable development, it maintains both qualitative and quantitative characteristics. It must be differentiated from growth that applies only to a quantitative increase in physical dimensions.

This report starts with the identification of a system that includes people, the enveloping ecosystem, and the interaction between the two. The word "sustainability" can apply to this system. However, because of the interconnectedness of the ecosystem and people, reporting on progress toward sustainability, in this context, cannot be differentiated from reporting on progress toward sustainable development.[5]

A Brief Historical Note

A system for reporting on sustainable development is as important to Canada's future as its system for reporting economic activities has been for its welfare over the past 50 years.

Work on national accounting through the 1920s and 1930s in the United States, and during the late 1930s and the 1940s in Great Britain, led to the system that is now used throughout the world. A key contribution was made by John Maynard Keynes who provided the crucial theoretical framework for calculating "national income" in the mid-1930s.

Now, half a century later, this system continues to be the subject of debate and is evolving constantly. The Standard Industrial Classification, which underlies the System of National Accounts, tracks a range of social and economic signals from close to 1,000 industrial

classes in Canada. It will similarly take time to develop effective ways of monitoring, assessing, integrating, and reporting progress toward the broader and more integrative concept of sustainable development.

The first formalized systems of reporting, at regular intervals, on the state of environment (SOE) began in 1969 in Japan and in 1970 in the United States.[6] As SOE reporting has matured during the intervening 25 years, Canada has played a leading role internationally, in terms of both conceptual developments and substantive developments.

Much of the effort spent in improving ways to assess progress has been directed at identifying better indicators. In the 1960s, the motivation was a desire to monitor the quality of life and social conditions more effectively. In the 1970s, it stemmed from a concern with environmental quality. In the mid-1980s, assessing the health of communities emerged as a concern and sets of "indicators of healthy communities" were developed.

In 1990, the issue of human development attracted attention with publication of the first annual report on the topic by the United Nations Development Program. Its human development index, although subject to much debate, is gaining recognition as a key indicator of human well-being.[7]

During these same 25 years, alternative approaches to economic monitoring have been proposed. Feminist scholarship has offered an especially useful perspective. Most recently, "ecological economics" has emerged as a transdisciplinary field that now has a formal society and a learned journal.[8]

Canada's system of health information has received critical scrutiny over the past decade as part of the overall concern with soaring health costs. New approaches to identifying the determinants of well-being, which include economic and environmental factors, are being explored.[9]

These various activities have all dealt, to a greater or lesser extent, with the prosperity, health, and overall well-being of people, on the one hand, and with the integrity, health, and overall well-being of the ecosystem, on the other.

In the late 1980s, and now in the 1990s, popularization of the concept of sustainable development brought a new wave of interest in improved indicators. As a result, the 1989 G-7 Economic Summit, held in Paris, requested that the Organization for Economic Co-operation and Development (OECD) address this issue. Canada signalled its intention to play a leading role, and a number of initiatives resulted, including those of Environment Canada (Indicators Task Force),[10] Health and Welfare Canada (Steering Committee on Indicators for a Sustainable Society),[11] and the Canadian Environmental Advisory Council (Indicators of Ecologically Sustainable Development).[12]

An early attempt to assess progress toward sustainable development in Canada is contained in *Canada's National Report* to the Earth Summit held in Rio de Janeiro, Brazil, in 1992.[13] Meanwhile, round tables in most provinces and territories have developed, or are in the process of developing, sustainable development strategies. And at the federal level, a multistakeholder "projet de société" is charged with developing a national strategy for sustainable development.

In the private sector a number of individual firms and industry associations have established codes of practice and are implementing innovative approaches to reporting.[14] The Canadian Labour Congress, in conjunction with the National Round Table, has published a book explaining the

concepts of sustainable development and offering guidelines for action.[15] Individuals and families are striving to decrease the environmental impact of their activities. And the future of Canada's aboriginal peoples is being fashioned with reference to their historic wisdom that recognizes the profound link between the land and the well-being of people.

Most importantly, the concept of sustainable development has finally provided a mechanism for bridging many disparate disciplines and interests. It is our hope to build on the above work and facilitate the involvement of the many stakeholders that now claim some ownership in the idea of sustainable development. The proposed approach to reporting does this by explicitly linking decision making to the ecosystem, to people, and to interactions between the two.

Starting Points

Goals and Objectives

The overarching goal of reporting on sustainable development is to improve the way we make decisions. The means of reaching that goal will be to provide information that will support informed and responsible decision making. To do that, four specific objectives are proposed, and they are to:[16]

- communicate key signals to targeted decision makers, in particular, to give them early-warning signals for required policy or institutional changes;
- ensure accountability;
- encourage initiative by giving credit where credit is due; and
- identify knowledge gaps and provide rationales for giving priority to filling those gaps.

Reporting To, By, and For Whom?

These initial objectives lead to the identification of two categories of reporting, one in support of ongoing management and decision making, and a second related to accountability.

The first category is reporting *to* decision makers *for* decision making.

The second is reporting *by* decision makers (or organizations as a whole) to those to whom they are accountable for their decisions or performance.

Reporting to decision makers calls for data, information, and analyses assembled as input to routine decision making related to the ongoing "business" and management of individual and household daily life, corporate activities, and governance.

Generally such decision making is future-oriented because it addresses the routine needs of decision makers in their ordinary responsibilities of deciding what to do next. Control of this reporting is exercised by the decision makers themselves, on the basis of their own perceived needs. Key considerations include accuracy, technical capability, and uncertainty about relationships between decisions and actions and between past states and projected futures.

Corporate and government examples of reporting to decision makers abound, and

range from lengthy reports by outside consultants or internal advisers, to highly condensed briefing documents. These reports can include information on current and past states, and they can relate to the decision topic, trends, identification of scenarios, projections, and assessments. For governments and larger corporations, there often is some organized capability to do research.

For most small businesses, individuals, and households, such reporting is likely to be much less formal. Usually individuals must rely on either their own data and knowledge (as in reviewing the cost of heating oil use to help make a decision about increasing insulation), or on research done by others (as in researching a proposed purchase by looking at publications providing advice to consumers).[17]

Reporting by decision makers, although similar in scope and content to the first category (i.e., it may contain information on past and present states, as well as trends, projections, and assessments), nevertheless has a quite different driving motivation. Private-sector examples include annual reports to shareholders. For the federal government, the Public Accounts serve the same purpose. Since this type of reporting offers decision makers an opportunity to present their actions in a positive light, a key issue often is the credibility of the information reported.

Reporting on sustainability must include both categories of reporting.

Achieving Results

There is an obvious danger that reporting on sustainable development could become a vast task, with no immediate tangible results. That would be completely unacceptable. While the existing data and information base is immense, a number of experiments have been completed that we can build upon. And there are interim steps that can be taken that will yield immediate results while a more comprehensive system is evolving.

Reporting as Part of Decision Making

Any system of reporting is nested within a larger decision-making system. Within that larger system, each society has different groups of decision makers who operate within cultures that are characterized differently in terms of values, motivation, and needs.

For example, the "corporate culture" is different from the "bureaucratic culture," which in turn is different from the culture of academics – and so forth. To be broadly applied, a system of reporting on sustainable development must be adaptable to all these different cultures and, at the same time, be tailored to the specific needs of the decision-making groups that represent those cultures.

In western, market-driven democracies, the following four decision-making groups are likely to be the most significant:

- individuals and households;
- corporations and corporate groupings;
- communities and settlements; and
- regional, provincial, and national governments.

This identification of key groups is pragmatic, although it could be seen as extending the three components of the conventional model of the market economy (firms, households, and governments) in order to recognize communities.

Fresh Perspective on Values

Decisions are based on values. A decision seeks a result and that result is desired because it is seen to be a beneficial thing. And it is seen as beneficial because the decision maker

Table 1
Value-driven characteristics of a system of reporting on sustainable development[18]

A system of reporting on sustainable development should focus on:

respect and concern for the ecosystem – by

- using a time horizon that captures both human (short) and ecosystem (long) time scales;
- adopting a frame of reference for assessing actions and decisions that extends beyond political and other boundaries to encompass the full extent of affected ecosystems; and
- analysing individual ecosystem components (e.g., air, groundwater, surface water, soil, fauna, flora, etc.) within the context of the connected ecosystem.

the interaction between people and the ecosystem – by

- being sensitive to the complete range of chemical, physical, and biological stress on the ecosystem – including stress that occurs naturally and stress that is imposed by human activities;
- adopting an anticipatory perspective when dealing with the manner in which indicators, time horizons, and analyses are expressed, so that in the reporting process there will be a forward-looking thrust instead of just a description of past and current conditions; and
- recognizing and accepting uncertainty as an inevitable occurrence instead of an impediment to good decision making.

respect and concern for people – by

- using assessment criteria that respect the existence of alternative and changing values when evaluating progress;
- assessing the distribution of environmental, economic, social, and cultural costs and benefits by examining their impacts on different social groups;
- using both
  - objective data and information, and
  - subjective information, i.e., intuitive understanding based on experience of everyday life, including experience gained from subsistence and traditional lifestyles.

has rated it according to his or her value system and has said it rates high enough to be wanted.

If sustainable development succeeds, it will be because we have adjusted our value system. It will be because we have extended our measure of worth and because we have placed the concept of well-being at the centre of our considerations.

At the heart of sustainable development is the holistic perception that the well-being of people depends on the well-being of all other parts of our world – and that means the well-being of the ecosystem, the well-being of our economic system, the well-being of our institutions, and the well-being of societies.

The litmus test, however, is people. If their well-being is denied, there will be consequences that will upset any and every balance, whether those consequences take the form of unrest, dysfunctional societies, commodity scarcities, economic dislocation, ecological degradation, atmospheric change, or institutional gridlock.

Developing a system of reporting on sustainable development provides an opportunity to nourish a growth in our perception of what is beneficial and what it is that we should want.

In practical terms, the value set underlying the ideas of sustainable development can be described as being based on a parallel care and respect for people and the enveloping ecosystem of which we are part. The implications of this value set will vary for any group of decision makers.

When this value set is applied to reporting, it channels attention in specific ways so that we approach indicators from a different viewpoint – as if we carried a checklist to ensure that they incorporated the things we think are important. If the indicators do not pass the test, then we can revise them until they do.

In other words, we seek to ensure that the indicators will have value-driven characteristics that reflect the parallel care and respect that we are talking about.

We offer such a checklist in Table 1 to indicate the kinds of things that indicators should reflect. The table is presented to stimulate reflection and discussion. Each decision-making group must deal with this topic on its own terms.

Blueprint for Reporting

The Reporting Focus

The steps:
- building an overlapping consensus
- constructing a template that reflects the main areas of diagnosis:
  - ecosystem health and integrity
  - human-ecosystem interactions
  - human well-being
  - an overall synthesis
- offering a recipe for reporting on sustainable development (two examples)

Building an Overlapping Consensus

This work draws on the concept of "overlapping consensus" first proposed in 1987 by Professor John Rawls of Oxford University. Professor Rawls pointed out that a consensus affirmed by "opposing theoretical, religious, philosophical, and moral doctrines" is likely to be both just and resilient. Consequently, public policy based on such an "overlapping consensus" is likely to thrive over generations.[19]

So, seeking such longevity for our proposals, we drew insights from a broad range of disciplines and interests in an attempt to identify common ground for designing a blueprint for reporting. A wide range of relevant theoretical and practical contributions were reviewed and then linked with the "value-driven characteristics" of a reporting system, which are identified in Table 1.

The Template

What we ended up with were four focal points that we think are the most important places to look in order to assess progress toward sustainable development. We call them areas of diagnosis, or, to present a less formal way of putting it, indicator domains.

In addition, our review highlighted once again how wide-ranging are the economic, environmental, social, and cultural concerns that affect progress toward sustainable development. What follows are the four indicator domains that we identified, and what there is about them that needs to be considered:[20]

I Ecosystem
An assessment of the integrity, health, or well-being of the ecosystem;

II Interaction
An assessment of the interaction between people and the ecosystem: how and to what extent human activities contribute to the provision of basic needs and the quality of life; how these actions stress, or contribute to restoring, the ecosystem; and how successful we have been at meeting the goals and objectives of policies, regulations, and legislation;

III People
An assessment of the well-being of people in the broadest sense (individuals, communities, corporations, regions, provinces, nations, and other decision-making groups); the assessment should range across physical, social, cultural, and economic attributes; and

IV Synthesis
An assessment of the whole: looking at key linkages across the above three components.

Framing the indicator domains in this way achieves two things: it recognizes that people are part of the ecosystem; and it stresses that what has to be managed is human activity. This last is extremely important because of the long-held view that people could "manage" the environment. Such a view, because it offers a false premise, can lead only to misplaced policies. Society cannot "manage" the environment; society can only manage the activities of people – through policies, laws, and actions – and the activities of people, in turn, interact with the supporting ecosystem. Consequently, these indicator domains will constantly direct attention to the decision-making process.

Taken together, they define the bounds of reporting on sustainable development. They offer a template that can be placed over decisions to help assess the impact they will have on sustainable development – or over activities to see what impact they are having. They also can be used as a template to place over the welter of data and information facing us to help identify what are appropriate indicators. Most importantly, they encourage a perspective that emphasizes the total interdependence of human well-being and ecosystem integrity.

A Recipe

Box 1 applies this approach to two cases: one is a hypothetical assessment of the activities of a forest company; the second is an overall assessment of forest lands in Canada.

Ecosystem Indicators: Building on SOE Reporting

The initial building blocks:
- 20 years of SOE reporting in Canada
- existing federal, provincial, and corporate reporting activities
- understanding the difference between SOE reporting and reporting on sustainable development
- advancing the ability to assess ecosystem integrity

Twenty Years of SOE Reporting

Over the years, state-of-environment reporting has provided a great deal of information that will be valuable in developing a system for reporting on sustainable development. And as it has matured, Canada has played a leading international role both substantively and in conceptual developments.

Box 1
Two example outlines of reporting progress toward sustainable development

A hypothetical forest company report on progress toward sustainable development

I Ecosystem Integrity (natural, modified, cultivated, built)
- assessment of the health and integrity of the ecosystem with which the corporation interacts.

II Interaction
- assessment of the stress caused by the activity (physical, chemical, biological); data in a form that compares with that of other corporations around the world;
- identification of opportunities for stress reduction; success in reducing stress;
- opportunities for, and success at, restoration;
- record of compliance with laws and regulations.

III Well-Being
- corporate well-being (financial and otherwise);
- profile and valuation of corporate activities (benefits contributed to shareholders, employees, communities, etc.);
- well-being of the community with which the corporation interacts.

IV Synthesis
- links across the above; assessment of the "whole"; anticipatory assessment.

A hypothetical assessment of progress toward sustainable development in Canada's forest lands

I Forest Ecosystem Integrity (natural, modified, cultural, built)
- assessment of the health and integrity of Canada's forest land ecosystems.

II Interaction
- assessment of stress on the ecosystem (physical, chemical, biological); data in a form that compares with that from other parts of the world;
- identification of opportunities for stress reduction; success in reducing stress;
- opportunities for, and success at, restoration;
- record of compliance with laws and regulations.

III People and Canada's Forest Lands
- assessment of well-being (individuals, families and households, communities, corporations, the forest industry, tourism and recreation, etc.);
- profile and valuation of human activities in, and dependent on, forest lands in Canada.

IV Synthesis
- links across the above; assessment of the "whole"; anticipatory assessment.

At home, Canadians established important milestones, including:

- a series of broadly interdisciplinary river basin studies, completed in the 1970s and 1980s by federal-provincial-territorial teams created under the Canada Water Act (1970);
- a comprehensive study of the Great Lakes ecosystem by the Pollution from Land Use Activities Research Group (PLUARG), created by the 1972 Great Lakes Water Quality Agreement. It led to entrenchment of the "ecosystem" approach to management of the Great Lakes system in the 1978 Great Lakes Water Quality Agreement;
- the first state-of-environment report completed in Canada. It was called

Environmental Quality in the Atlantic Provinces and came out in 1979 as a joint publication of Environment Canada, on the one hand, and the governments of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland, on the other;

- publication by Environment Canada of *The State of Canada's Environment*, first in 1986, and again in 1991; simultaneous publication by Statistics Canada of the statistical compendium *Human Activities and the Environment*;
- publication in 1987 of the first municipal SOE report in Canada by the Regional Municipality of Waterloo;
- the 1991 publication by Forestry Canada of its first annual assessment of *The State of Canada's Forests*;
- the release in 1992 of the federal government's *Green Plan*, which included a range of commitments directly related to reporting;
- the 1991 publication by Environment Canada of *A Report on Canada's Progress Towards a National Set of Environmental Indicators*;
- the joint publication in 1992 by Environment Canada and Statistics Canada of *272 Databases for Environmental Analysis*, which is a description of active databases within the federal system;
- the 1992 publication by Statistics Canada of *Households and the Environment, 1991*;
- the 1993 launch by Statistics Canada of the first of a new occasional series entitled *Environmental Perspectives, 1993: Studies and Statistics.*

Existing Reporting Activities

Opportunities for stakeholder participation have been significantly expanded during the past decade because of activities related to state-of-environment reporting within the SOE Reporting Branch of Environment Canada and the National Accounts and Environment Division of Statistics Canada. At present, a new memorandum of agreement is being negotiated between Statistics Canada and Environment Canada that will forge still stronger data/information links between the two organizations and further help overcome fragmentation in data/information gathering and assessment.

Several other federal departments and agencies publish periodic reports on various aspects of Canada's environment. They include: Fisheries and Oceans Canada, Agriculture and Agrifood Canada, Natural Resources Canada, and, within Environment Canada, the Atmospheric Service, the Ecosystem Science and Evaluation Directorate, and the Parks Service.

The Canadian Council of Ministers of the Environment (CCME) has a State of Environment Reporting Task Group that is trying to harmonize SOE activities among the provinces, the territories, and the federal government. Three major workshops have been held that have led to concrete advances supported by all 13 jurisdictions. The current emphasis is on developing an inventory of provincial environmental databases that can link to the Environment Canada/Statistics Canada inventory.

Most provinces have produced SOE reports covering their jurisdictions, and with the emergence of provincial round tables, the SOE reporting process is being linked with provincial strategies for sustainability (as in British Columbia and Ontario) or sustainable development (as in New Brunswick).

Some of the most exciting initiatives are being pursued by local governments across Canada that are undertaking SOE analyses.

A growing number of corporations also are developing a capacity for "environmental reporting." These reports focus on company activities and the stress they impose on the ecosystem – such as the levels of contaminants emitted, and the actions and expenditures undertaken to reduce them. They do not address the "state" of the receiving environment.

The Difference between SOE Reporting and Reporting on Sustainable Development

Clarifying the relationship between SOE reporting and reporting on sustainable development is a key issue. We have concluded that in terms of the indicator domains (ecosystem, interaction, people), the appropriate focus of SOE reporting is an assessment of:

- ecosystem integrity or well-being; and
- how and to what extent human activities stress or restore the ecosystem. (This component is part of monitoring and assessing human-ecosystem interaction.)

This definition of bounds is consistent with the four questions that conceptually drove Canada's 1991 SOE report. They were:

- What is happening in Canada's environment?
- Why is it happening?
- Why is it significant? and
- What are Canadians doing about it?

However, it also signals our conclusion that SOE reporting is a critical subset of a broader system of reporting on sustainable development that must provide an overall perspective. To date, that broader system of reporting has not been encouraged.

Advancing the Ability to Assess Ecosystem Integrity

Finally, it is important to highlight a conclusion regarding Canada's current ability to monitor and assess ecosystem conditions. While there is a massive amount of literature available that describes the state and trends of various components of Canada's ecosystem, natural scientists remain at the earliest stages of being able to effectively monitor and assess ecosystem health and integrity. Ongoing support is critical – within governments and universities, and beyond – if we are to progress on this front.

Interaction Indicators: Building on Economic and SOE Reporting

How to report interaction:

- factors controlling interaction between people and the ecosystem
- human activities as the motor of the reporting system
- drawing from macroeconomics
- addressing non-market activities and unquantifiable values
- the key role of the financial services industry
- strengthening the focus on stresses other than "pollution"
- extending current reporting

Factors Controlling Interaction

Interaction between humans and the ecosystem is controlled by two sets of factors:

- natural conditions and events that determine the circumstances in which people, as a subsystem, function; and

- human activities that draw on the ecosystem for support. (Usually these activities impose stress on the ecosystem, but in some special cases they can help restore certain of its functions, for example, by building fish ladders around dams or other obstructions in rivers.)

Human Activities as the Motor

Society does not manage the environment. It manages human activities, which, in turn, interact with the supporting ecosystem. It follows, then, that analysing the interaction between people and the ecosystem is dependent on understanding, describing, and classifying human activities. In principle, monitoring and assessing the interaction should concentrate on how:[21]

- human activities provide for basic needs and contribute to an enhanced quality of life. In other words, it should take into account the value of those activities to individuals, households, communities, corporations, regions, provinces, or the nation as a whole;
- human activities stress the ecosystem physically, chemically, and biologically;
- stress on the ecosystem, in turn, produces short- and long-term implications for people, for the activities in question, and for the ecosystem; and
- some human activities provide opportunities to reduce stress on, and restore functions to, the ecosystem.

A complete classification and description of human activities does not exist.[22] However, the Standard Industrial Classification (SIC), which categorizes "value added" according to market activity, offers a useful starting point.

Drawing from Macroeconomics

It is here that the power of economics and macroeconomic analysis should be brought to bear as a critical part of reporting on sustainable development – and there are four reasons for doing so:[23]

- the majority of human activities that are overstressing the ecosystem are found within the market system;
- Statistics Canada databases, organized according to the SIC, offer the most complete and long-term quantitative description of human activities available;
- using SIC categories will link reporting to current decision making; and
- current work on natural resource satellite accounts to the System of National Accounts is linked to the same SIC categories.

Thus, the starting point for reporting on the "interaction" is traditional macroeconomic reporting and analysis. For national and provincial reporting, that means dealing with the System of National Accounts (SNA) and its provincial equivalents. For corporations it means starting with their own financial statements.

For communities there is a problem. While a municipal government can deal with itself as a corporate entity through its own accounting, it is usually difficult to obtain anything more than a crude macroeconomic picture of the community as a whole. Databases created by provincial and federal agencies are not usually aimed at assisting community decision makers, and communities rarely have the resources to generate their own.

Individuals and households usually have an understanding of their overall finances, but they rarely examine the longer-term implications of the various activities that fill each day. However, there are a number of sources to which they can turn for information.

For any person, corporation, or body seeking information, Statistics Canada collects and analyses data on a formidable array of demographic, economic, and socioeconomic topics, listing close to a thousand in its 1993 catalogue. Moreover, it is doing its best to present them in user-friendly formats. (Its user-pay policy, however, is a barrier to many individuals.) In addition, most federal and provincial departments regularly report on their mandates in economic terms and these, too, can be a valuable source of information.

A variety of non-government groups also play a significant role, including the Conference Board of Canada, the Canadian Real Estate Board, Dow Jones, the major banks, and a number of investment firms, to name a few. In addition, reports prepared by various United Nations agencies, the OECD, and the World Bank offer an important international perspective. For many people, newspapers are a dominant source of economic information.

Non-Market Activities and Unquantifiable Values

There are three important limitations on Canada's financial reporting system, all of which relate to what the system does not or cannot offer. In the first place, there are many human activities that lie outside traditional economic topics because they are not necessarily motivated by a desire to produce goods and services for exchange in the market system. Consequently, they are not reported. Nevertheless, they contribute greatly to the well-being of Canadians and, at the same time, they impose significant environmental stress.

The most stark example is housework, most of which is performed by women. In 1992, Statistics Canada conservatively estimated that the value of household work in Canada was from 32 percent to 39 percent of gross domestic product (GDP), or about $159 billion to $199 billion.[24] A second example is the large range of volunteer activities. For 1986-87, Statistics Canada estimated that 5.3 million Canadians undertook volunteer work, contributing more than a billion hours of their time, worth about $12 billion (using an average service-sector wage).[25]

Secondly, under current macroeconomic techniques, it is difficult to assess unquantifiable values. A large range of environmental and social factors are simply not included in the theoretical and conceptual models that drive economic analysis. Examples include air, water, biodiversity, artifacts of human history and culture, and so forth.

Thirdly, when calculating return on investment or, in general, when assessing success, financial analysis does not deal with the range of physical, chemical, and biological stress imposed on the ecosystem by economic activity.

In fact, economic indicators such as GDP ignore environmentally destructive impacts in recording economic activity. Consequently activities are recorded as economic benefits regardless of how destructive they may be. This practice gives rise to the current paradox of "mutually incompatible descriptions of well-being" in which economists rightfully point to increasing standards of material welfare while ecologists rightfully point to the threat posed by rising consumerism to the planet's life-support systems.[26]

The Key Role of the Financial Services Industry

It is the financial services industry that is leading change toward recognizing the environmentally destructive consequences of economic activities. Spurred by the threat of legal liability and substantial penalties, it is seeking

ways to better protect investments. As a result, it is beginning to adopt procedures for risk analysis that recognize and deal with at least some long-term environmental implications.[27] So far, however, the only issues to be addressed have been contaminated land and groundwater, concerns that have been recognized as serious problems for two decades. The industry has not yet adopted a broader, anticipatory stance.

However, these two concerns, especially that of groundwater, illustrate the difficulty faced in economic analysis and decision making in dealing with long-term, intergenerational time horizons. More exactly, they demonstrate the incompatibility between economic analysis that employs short time horizons (generally a few years) and the time horizons governing natural processes (many thousands of years and more).

At the same time, experience with these two concerns has spread awareness of the potential magnitude of environmental risk and sparked recognition of the positive spin-offs that can flow from environmentally sensitive management. For example, minimizing waste and the use of resources has major economic, as well as environmental, benefits. Similarly, effective management of forest activities can improve biodiversity over the long term and lead to a net increase in positive benefits for people.

The initiatives being taken in the financial services industry represent a substantial institutional change that has significantly improved awareness in the corporate world. It underlines the importance of clearly signalling incentives if change is to be promoted.

Strengthening the Focus on Stresses other than "Pollution"

Assessing stress on the ecosystem has been a central concern of state-of-environment reporting. However, as noted in the section dealing with Ecosystem Indicators, it needs to be broadened to provide close attention to assessing how human activity links to ecological stress and to those special cases where it links to restoring the ecosystem.

Although the emphasis on chemical "pollution" is appropriate as a top current priority, it is important to recognize that the stresses that people impose on the ecosystem are physical and biological, as well as chemical. For instance:

- damming, dyking, dredging, and infilling can severely affect lakes, waterways, wildlife, microclimates, and ecosystem dependencies;
- expansion of farmlands can significantly impair biodiversity;
- urban sprawl can seriously reduce available farmland;
- insensitive commercial forestry practices can adversely alter regional ecosystems and microclimates, and can result in land degradation;
- discharges of heated water into waterways can dramatically affect aquatic life;
- extraction of non-renewable resources can give rise to remote human settlements that will create pressures on surrounding ecosystems;
- noise can seriously affect people, raising tensions, causing hearing damage, limiting sleep, and contributing to psychological problems. It also can affect wildlife, and their reaction can, in turn, disturb ecological balances;
- non-native plants, aquatic life, and other species can be introduced, intentionally or unintentionally, and have major impacts – three relatively recent examples of unintentional invasion are zebra mussels in the Great Lakes system, milfoil weed in British Columbia lakes, and purple loosestrife in Ontario wetlands; and

- land use – everything from super-highways, to pipelines, cottage development, lot severances, and urban sprawl – can add stress to the ecosystem.

Table 2 lists three types of stress and the human activities that produce them.

Table 2
Human activities grouped to show stresses as physical, chemical, or biological[28]

Induced stress "type"	Human activity
Physical	Physical restructuring
	Land-use change
	Erosion and sedimentation
	Discharge of heat
	Noise generation
	Extraction of non-renewable resources
Chemical	Discharge of chemicals
Biological	Harvest of renewable resources
	Various forms of habitat disruption
	Accidental or planned introduction of non-native species
	Biotechnological manipulation

Extending Current Reporting

It is apparent that to monitor and assess human-ecosystem interaction, reporting on sustainable development must deal with a universe of data and information that extends well beyond the bounds of traditional financial reporting in terms of:

- the breadth of activities considered;
- the nature of the assessment that takes place; and
- the time horizon of assessments.

Nevertheless, the focus of reporting on interaction clearly should be on classifying and assessing human activities. And it is economics that provides the best starting point.

People Indicators (Human Well-Being): An Interdisciplinary Morass

Seeking a more holistic approach:

- health as complete physical, mental, and social well-being
- weaving development around people, not people around development
- the Newfoundland lesson: the need for an enormously broad range of disciplines
- initiatives

Health as Complete Physical, Mental, and Social Well-Being

For two decades in Canada there has been an official and determined effort to expand the idea of health into a more holistic notion of well-being. In 1974, the then minister of health, the Honourable Marc Lalonde, proposed a concept of health that linked the environment, human biology, lifestyle, and health care organization.[29] In 1977, Canada formally committed itself to a definition put forward by the World Health Organization (WHO) that described health as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity." In 1986, the WHO, Health and

Welfare Canada, and the Canadian Public Health Association used this definition as a starting point for the *Ottawa Charter for Health Promotion.*

The charter demonstrated just how wide-ranging can be the factors that influence health – when health is defined as well-being. It identified peace, shelter, food, education, income, social justice, equity, maintenance of a stable ecosystem, and sustainable resource development as prerequisites to health. Many of these same factors were identified as critical components of sustainable development by the World Conservation Union, the World Wildlife Fund, and the United Nations Environment Program in their 1992 publication *Caring for the Earth.*[30]

In its *Human Development Report 1993,* the United Nations Development Program (UNDP) pointed out that while progress had been made during the past three decades, "our world is still a world of difference." It is important for Canadians to be familiar with the global context presented in the report because the interlocking nature of sustainable development issues means that problems in one part of the world can contribute to problems that affect everyone. For instance, there are clear links between Third World poverty and high population growth, deforestation, land degradation, and climate warming. The report says that:

> *More than a billion of the world's people still languish in absolute poverty, and the poorest fifth find that the richest fifth enjoy more than 150 times their income. Women still earn only half as much as men – and despite constituting more than half the votes, have great difficulty securing even a ten percent representation in parliaments.*[31]

Weaving Development around People

The United Nations report further points out that:

> *Development must be woven around people, not people around development, and it should empower individuals and groups rather than disempower them. . . Markets need to be reformed to offer everyone access to the benefits they can bring. Governance needs to be decentralized to allow greater access to decision making. And community organizations need to be allowed to exert growing influence on national and international issues.*[32]

Since the inception of the UNDP's human development index (HDI) in 1990, Canada has ranked either first or second overall. In 1993, however, an additional figure was published. It was the HDI adjusted for gender disparity, and in that rating Canada fell from second to eleventh place. In addition a third figure, the HDI adjusted for income distribution, showed that Canada dropped from second to sixth place.

The Newfoundland Lesson

The breadth of the disciplinary interests that must be brought to bear in assessing progress toward sustainable development is more evident in discussions of health and human development than in any other aspect of reporting. The degree to which health, work, and play depend on environmental integrity is direct and powerful. No better example exists in the world of this set of relationships than that provided by the demise of the North Atlantic cod populations and the resulting crisis for Newfoundland fishers and their communities. This is not just an environmental catastrophe; it is a human calamity as well.

If warning signals are to be recognized in time to prompt action before there is a crisis, reporting must cover a full range of indicators. And how broad that range is can be seen most clearly in the area of monitoring and assessing human well-being. In part, it is clearer here because human well-being deals with an aspect of sustainable development that comes closest to each and every one of us. And the lesson is obvious: sustainable development involves linkages that reach into every corner of life – environmental, economic, cultural, social, and political.

To monitor and assess the human dimension of sustainable development, insights must be drawn from a large number of disciplines. But the turf of these disciplines often lies protected by broad moats and high walls founded on language and concepts that only the initiated can fathom. To bridge this interdisciplinary morass is one of the core challenges of reporting on sustainable development.

Initiatives

In 1991, the National Task Force on Health Information, a joint initiative of the National Health Information Council (NHIC), the Conference of Health Deputy Ministers, and the Chief Statistician, Statistics Canada, declared that the system of "health information in Canada is in a deplorable state."[33] As a result, the NHIC, working with Statistics Canada's Centre for Health Information (CCHI), is developing a new System of Health Statistics for Canada. It is a very timely initiative, given the escalating costs of health care, and growing unease about potential links between human health, chemical contaminants, and other factors contributing to ecosystem degradation.

CCHI is responsible for conducting the Canada Health Survey, the last of which occurred in 1978. The next is scheduled for 1994. Other smaller, more specific surveys, are conducted by Statistics Canada, primarily for Health Canada. Both Ontario (in 1990) and Quebec (in 1992) also conducted major health surveys. Other provinces and territories are waiting for the 1994 Canada Health Survey. Health information also is collected and disseminated by other divisions, and arm's-length affiliates, of Health Canada, and by provincial and municipal counterparts.

Over the past five years, a number of initiatives have departed from the traditional approach and taken up the challenge of developing a more holistic approach to health determinants. For example:

- the Healthy Communities movement has based much of its development of healthy community indicators on the conceptual work of Dr. Trevor Hancock. This identifies:
  - environmental well-being (viability),
  - economic well-being (adequate prosperity), and
  - community well-being (conviviality)

  as fundamental factors for maintaining sustainable, livable, and equitable communities;[34]
- Health Canada's Steering Committee on Indicators for a Sustainable Society includes environmental, economic, equity, and health factors in its conceptual approach;[35]
- the National Task Force on Health Information proposes a template for assembling health information that is based on recognizing that a person's health is determined in the interaction between his or her individual characteristics and external influences that are:[36]
  - physio-chemical,
  - economic,
  - socio-cultural, and

  - features of the health care delivery system;
- within Health Canada there is a growing emphasis on linking health and the environment, and it is reflected in:
  - the department's 1992 report *A Vital Link – Health and the Environment in Canada*; and
  - the pioneering work of the Great Lakes Health Effects program;
- ongoing conceptual work of the Canadian Institute for Advanced Research links the interaction of:[37]
  - the physical environment,
  - the level of prosperity, and
  - the social environment

  with
  - genetic endowment,
  - health care,
  - disease, and
  - health and function.

  It also links an individual's response to this interaction (both in behaviour and in biological development) with the overall generation of well-being. It then shows how the degree of well-being feeds back to influence other parts of the system;
- the Canadian Medical Association has developed a model of health and sustainability that includes environmental, economic, and health components;[38]
- the Canadian Public Health Association has established a Task Force on Human and Ecosystem Health; and
- the Global Change Program of the Royal Society of Canada has established a Health Committee.

In addition to these health-based initiatives, many other disciplines are involved in defining and understanding human well-being. Philosophy, religion, and practical ethics lay claim to the very foundation of the topic. Psychiatry, psychology, and sociology focus on the individual personality and the health of individual-family-community relationships. Since the 1970s, and in some cases earlier, landscape architecture and land-use planning have been involved in systematic attempts to understand individual, household, and community well-being in relation to physical and social environments. Much of this is captured in quality-of-life literature.

All of the above initiatives, and the related literature, contribute insights that will help in the assessment of the human dimension of progress toward sustainable development in Canada. However, none has offered a satisfactory overall solution to the reporting challenge.

Integration and Synthesis

Building roadmaps to anticipatory thinking:
- making the most of the bridging power of sustainable development
- improving information systems so that they will support integrative long-term, anticipatory analysis and decision making
- putting the seventh-generation principle of aboriginals into practice

The Bridging Power of Sustainable Development

More than anything else, the power of sustainable development lies in its bridging capability – its ability to facilitate integration, synthesis, and collaborative approaches to problem solving.

In a similar way, state-of-environment (SOE) reporting has been motivated by a desire for integration and synthesis. Drawing on ecosystemic principles, SOE reporting has taken the lead in struggling with the issue of cumulative effects and of identifying and

assessing cause-effect relationships when hard evidence is scant, or non-existent. Some of the strongest experience in integrating human and ecosystemic issues has occurred at project levels where there have been environmental impact assessments (EIA) that include social impact assessments.

Reporting on sustainable development should build on this experience. But reporting on sustainable development is not SOE reporting or environmental impact assessment extended, just as it is not economic, health, quality-of-life, or law reporting extended. Its power lies in its acknowledgement that all of these facets of reporting, and others as well, have an important role to play. The unique contribution that reporting on sustainable development offers lies in the potential it has to provide a roadmap that will link all these interests.

Improving Information Systems

A bridging approach is long overdue. Experience with the Great Lakes ecosystem serves to illustrate. The first assessment of pollution problems was completed in 1912. In the 80 years since then, thousands of reports have been written that deal with some aspects of that ecosystem – such as the Great Lakes economy, human activities and how they are stressing the ecosystem, and human health. Only three have tried to integrate across this spectrum of concern.

The need for more integrative approaches to policy development in Canada was recognized as early as 1948 when conservation authorities were established in Ontario. They were organized on the basis of drainage basins and given certain integrating responsibilities. In the 1970s, large integrative water-basin planning studies came into vogue and a number were completed in various parts of Canada. However, the results of this work remained distant from mainstream politics.

In the late 1980s, the political situation began to change. The Yukon government set a leading example of integration with its 1988 long-term economic strategy called Yukon 2000. The ecological principles that were incorporated into Yukon 2000 were subsequently echoed in the government's 1990 Conservation Strategy. Canada is not alone in its initiatives; many countries around the world have adopted integrative strategies for sustainable development.

As a reflection of the approach taken by society as a whole, corporations and governments generally adopt a "react and cure" attitude that leads to sectoral divisions in policy making. Institutional arrangements parallel and reinforce this compartmentalizing of responsibilities, as do the resulting information systems. Not surprisingly, these information systems tend to focus overwhelmingly on the immediate and do not provide much support for integrative policy development and decision making that deals with the very long term in an attempt to anticipate and prevent difficulties before crises occur.

We reach the following conclusions and observations:

1. the interpretive, anticipatory, and long-term perspective that is demanded by the idea of sustainable development points to a need for change in traditional government and corporate organizational structures and mandates;
2. only limited resources are available to reform and build on current reporting systems;
3. while important gaps exist, a powerful information base is available that cannot be put to effective use because of its compartmentalized nature;

4. it is vital that communities, corporations, and governments embed principles of sustainable development as basic values within their organizations, and that in rating performance, they place a high value on implementing sustainable development principles and on providing integrated monitoring, assessing, and reporting of progress; and
5. an important step for any organization is to charge an individual or an office with responsibility for monitoring, assessing, and reporting progress toward sustainable development.

The Seventh-Generation Principle

This last conclusion, if acted upon, will incorporate into decision-making structures the ancient aboriginal practice of investing a member of a tribal council with responsibility for speaking on behalf of people to be born seven generations hence, and calling on that person to assess what impact a decision would have on them.

Toward a Short List of Key Indicators

The scope of indicators:
- at present they address specific needs within limited fields
- in the future they should be trans-disciplinary with perspectives that are integrative and participatory
- in the meantime, developing a definitive set of indicators will require patience

Present Indicators

Within each indicator domain, there are indicators that are widely used. Box 2 offers a number of examples.

These examples demonstrate how wide is the area from which data and information need to be drawn in order to properly assess progress toward sustainable development. Individually, any one indicator sends an extremely limited signal to decision makers. However, together they form a useful "family" that can offer an overall sense of movement – one way or the other – even though the trends of individual indicators may be contradictory. In time, and as we gain experience in synthesizing the broad picture, a refined "family" of sustainable development indicators will emerge.

The indicators listed in Box 2 (and many others not listed) have gained prominence because they are useful within one field or another. Normally, they developed in isolation from disciplines in another field, and without any overarching link. In addition, how they are applied, or whether they are applied at all, depends on who is doing the applying – a national organization, a regional organization, a corporation, a community, a household, or simply an individual.

Future Indicators

A significant step toward development of trans-disciplinary indicators was taken in 1989 when the OECD was requested by the G-7 Summit,

> *. . . within the context of its work on integrating environment and economic decision making, to examine how selected environmental indicators could be developed.*[39]

In response, Environment Canada quickly established an Indicators Task Force to lead Canadian efforts.[40] And Health and Welfare followed by co-ordinating the creation of a Steering Committee on Indicators for Sustainable Development.[41] The Canadian Environmental Advisory

Box 2
A partial list of rudimentary indicators

I Ecosystem
- temperature (daily and trends over time);
- concentrations of contaminants in indoor and outdoor air that are: common (CO_2, NO_2 ground-level ozone, carbon monoxide) and toxic (dioxins, lead, etc.);
- concentrations of contaminants in water (mercury, DDT, PCBs, etc.);
- concentrations of contaminants in the tissue of fish, birds, wildlife, and humans (lead, PCBs, DDT, etc.);
- rates of soil erosion;
- acid deposition;
- loss of wildlife habitat;
- the state of biodiversity:
  - genetic (diversity within species), and
  - species (diversity in the number of distinct species);
- species health (births, survival rates, deformities, leaf or needle loss, etc.);
- population shifts of wildlife (eagles, caribou, counts of migrating salmon in the Fraser River, etc.).

II Interaction
- contribution to well-being by activity (value added by agriculture, manufacturing, financial services, housework, etc.);
- resource use (per unit of time, or per unit of output);
- generation of contaminant emissions:
  - heat and waste products per capita, or per unit of production,
  - loadings to air, surface water, groundwater, or land by activity (by automobiles, pulp and paper manufacturing, energy production, etc.), and
  - the totals for regions and the nation;
- proportion of materials recycled;
- renewable resource harvest rates;
- non-renewable resource extraction rates;
- degree of compliance with laws and regulations.

III People
- infant mortality rates;
- literacy rates;
- life expectancy at birth;
- incidence of disease;
- employment and unemployment rates;
- income levels;
- degree of pride in community and culture;
- corporate bankruptcies;
- level of indebtedness (individual, community, and nation);
- obesity (adults);
- malnutrition (children);
- caloric intake, and the proportion of it acquired from local, Canadian, and foreign foods.

Council commissioned several undertakings and brought Canadian experts together to brainstorm on the subject of "indicators of ecologically sustainable development."[42] It also was at this time that the National Round Table began work on defining indicators for monitoring sustainable energy production and use.[43]

In the Meantime . . . Patience

To achieve the kind of integrative and anticipatory reporting system that is required for sustainable development, it is essential to embrace a new, broader perspective that goes beyond environmental, economic, social, and cultural indicators. That perspective is found in the concept of sustainable development.

It is important to support ongoing work on new indicators in various fields. But it is even more important to encourage work that links these fields together. Finding out how to link these fields, identifying new and pertinent indicators, and – especially – establishing indicators that are integrated, transdisciplinary, and anticipatory is going to take time.

In the end, with patience, dedication, and a good deal of interdisciplinary co-operation, we may very well be able to identify a small list of key indicators of sustainability.

Decision Makers

Individuals and Households[44]

A focus on:
- Canada's people
- their reporting needs
- what information and data are available
- discussion and recommendations

Canada's People

According to the 1991 census, there were 27,296,859 people living in Canada in just over 10 million households. Three quarters were urban dwellers, one quarter were rural (see Figure 1).

Every day, in meeting basic needs and striving for an enhanced quality of life, individuals and families make decisions. They are the fundamental decision-making units of Canadian society.

Reporting Needs of Individuals and Households

It is practical information and data that people need. So, the following questions should be addressed:

- In terms of human well-being and the well-being of ecosystems, how does my home rate? And my neighbourhood, workplace, and community? What impact do their conditions have on me and my household? How do they compare with those of others?
- What stress (physical, chemical, or biological) do my activities, and those of my household, create – for instance, by our eating, recreation, travelling, buying patterns, and so forth? What benefits do we receive? How do our experiences compare with those of others?
- What activities in my workplace, neighbourhood, and community enhance or detract from the well-being of people and of ecosystems? How do these activities compare with what others are doing?
- What higher goals might we achieve, and how does my track record, and that of my household, measure up to those goals? What could we be doing that would improve our performance, and what impact would it have? What would be the difference if people and households undertook collective action?

What Information and Data Are Available?

With the exception of energy-use statistics from utilities, the vast majority of individuals and households do not get, and are not encouraged to generate, the kind of information that will answer the above questions in any systematic way. Computerized home audit programs are available, but they are not widely used. Consumer product information is available in popular literature and through programs such as the federal Environmental Choice Program, but it is far from enough. And information provided by manufacturers is mistrusted by most consumers.

In 1991, Statistics Canada completed a survey of *Households and the Environment*.[45] However, it was a once-only undertaking and there is no funding to repeat the survey at regular intervals. Provincial surveys, and the occasional large municipal survey, are completed sporadically. And municipal, provincial, and federal co-ordination in surveying is limited.

Until recently, sharing health records with patients was discouraged. Moreover, systematic collection and analysis of health statistics has been irregular. The good news, however, is that the situation will improve significantly with the development at the federal level of the new System of Health Statistics.

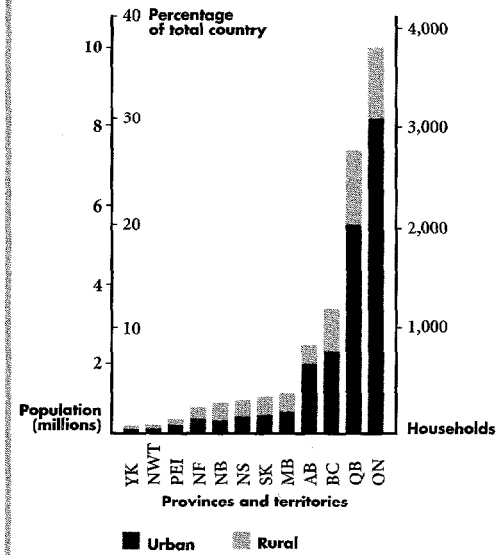
Discussion and Recommendations

The most significant and yet the least realized aspect of the entire issue of reporting on sustainable development may be the challenge of providing individuals and households with information. They need to know not only specific information about consumer purchases, but also, in a much broader context, about lifestyle choices.

Because of the importance of individuals and households as decision makers, the National Round Table has joined with ParticipACTION to develop a program to encourage them to become more knowledgeable about sustainable development and how they can promote it.

However, success in motivating people will be extremely limited if appropriate mechanisms are not put in place to gather key statistical data and information, and to gather it in a rigorous and ongoing way. Baseline information as well as trends over time are required. Given the cost, co-ordination, and expertise involved, it is essential that the federal government take a leading role, preferably through Statistics Canada, which already has the capability to collect such data and information.

Figure 1
Population and households by province and territory



The "urban" component includes all those living in a continuously built-up area having a population of at least 1,000 living in a density of 400 or more per square kilometre. All others are considered "rural".

Source: 1991 Census.

The most effective approach may be to modify existing reporting functions, such as that used for the *Labour Force Survey*. That is how the *Households and the Environment Survey* was completed in 1991.[46]

The National Round Table is aware of the large number of competing demands that the Chief Statistician must weigh in establishing priorities. Nevertheless, it wishes to emphasize how urgently individuals and households need data and information to chart a path toward sustainable development and to measure their progress.

We recommend that Statistics Canada:

a) systematically gather and periodically report data and information concerning individuals and households that is related to the state and progress of sustainable development; and, to that end,

b) join with the National Round Table and ParticipACTION in their social marketing initiative to jointly:

- ***design, develop, and launch a national sustainable development home survey and report-back program; and***
- ***motivate people to participate.***

The program will provide an opportunity for Statistics Canada to develop and implement an ongoing individual and household database that has information from all parts of Canada. It should aim at enabling individuals and households to monitor, assess, and report their activities and to compare them with local, regional, provincial, and national averages.

Consumer buying habits that are sensitive to sustainable development concerns are essential to any progress. Consequently, Environment Canada has established a project, the Environmental Choice Program, in which manufacturers voluntarily participate. Individual products are assessed and, if certain environmental standards are met, they are awarded recognition and the right to carry an Environmental Choice logo. Information describing the successful products and the relevant standards is also made available to consumers.

The National Round Table is concerned that the single-ministry focus of this program has limited its effectiveness. Within the federal government, consumer-related responsibilities are shared – at the very least by Environment Canada and by Industry Canada. If there were a similar sharing of responsibility for the Environmental Choice Program, the program could draw upon more extensive expertise and enjoy a wider base of support.

We recommend that the Government of Canada:

Restructure the environmental choice program to be a joint responsibility of Environment Canada and Industry Canada.

In follow-up, every effort should be made to expand the program to cover a broader range of products and to upgrade program marketing to ensure more effective outreach.

Communities[47]

A focus on:
- what is a community
- reporting needs of communities
- what information and data are available
- discussion and recommendation

What is a Community?

A group of people can be called a community if:
- membership in the group contributes to self-identification;

- there is extensive participation by its members in the decisions by which its life is governed;
- the group as a whole takes responsibility for its members; and
- this responsibility includes respect for the differences among these members.[48]

By this definition, a community could be based on ethnicity, gender, religion, geography, politics, or interest.

In gathering statistics on communities, however, data and information are not sought according to the above characteristics of a community. Instead, they are usually collected in relation to the existence of a local government, and this government may, or may not, reflect the sense of community as defined here. Nevertheless, there is a significant shift occurring in the Canadian mosaic as more and more jurisdictions assume greater responsibility for their own futures. One result is a strengthening of a sense of community as defined above.

The fundamental reporting unit within Statistics Canada is the *census subdivision*, which is usually a municipality or its equivalent, such as an Indian reserve, an Indian settlement, or an unorganized territory.

Where there is an urban area with a core population of at least 10,000, Census Canada identifies it as a *census agglomeration* (CA). Adjacent urban and rural areas, which have a high degree of economic and social integration with the core, are included within the CA. When the core reaches a population of 100,000, the area is designated a *census metropolitan area* (CMA). Statistics Canada also establishes as *urban areas* those locations that have a population of at least 1,000 and a density of 400 per square kilometre (see Table 3).

Provinces differ in how they identify communities (see Table 4). Their definitions are presented in a variety of statutes in which "communities" can include cities, municipalities, towns, villages, hamlets, and Indian reserves. And they may, or may not, conform with the statistical units established by Statistics Canada. Where they do not conform, usually it is possible to approximate the "community" area by grouping together enough of Statistics Canada's census subdivisions. However, Statistics Canada surveys are usually motivated by national data needs and, with the exception of work aimed at tracking conditions in large urban areas, analysing the data is rarely useful for community purposes.

Reporting Needs of Communities

Community decision makers should have access to data and information that:

- point to the integrity, or well-being, of the ecosystem with which the community interacts and how it compares to ecosystem conditions elsewhere;[49]
- outline:
  - activities undertaken within the community, how they provide for basic needs and enhance the quality of life, and how they stress or restore the ecosystem,
  - activities undertaken outside the community and how they add to the stress, or aid the restoration, of the ecosystem,
  - how all this compares to what is happening in other communities, and
  - how successful the community has been in meeting goals and objectives that have been set in policies, regulations, and legislation;
- measure the well-being of community members and the community as a whole, and compare the measurements to those in other communities across the country.

Once data and information are compiled on individual communities, one of the great spin-off advantages will be that they can become available to any other community that

Table 3
Communities defined by Statistics Canada

Region	Census subdivision	CAs	CMAs	Urban areas
Canada	6,006	115	25	893
QB	1,637	28*	6*	222*
SK	953	8*	2	69*
ON	951	32*	10*	246*
BC	691	22	2 9	2
AB	438	9*	2	99*
NF	404	4	1	42
MB	293	4*	1	42*
NB	287	5*	1	36*
PEI	126	2	0	7
NS	118	4	1	38
NWT	72	1	0	4
YK	36	1	0	1

* Communities crossing provincial boundaries are counted in both provinces.
Source: Statistics Canada.

wants to measure its performance against that of others. However, being available is different from being accessible. There is now, and there will increasingly be in the future, a need for efficient access to information about what is happening in other communities across Canada – describing their policies and programs (intentions and actions) relating to sustainable development. To this end, a national clearinghouse of information should be established.

What Information and Data Are Available?

It is lack of access to data and information, not lack of the data and information itself, that is seen as the greatest limitation. Municipal planning offices already use much census data. Nevertheless, there are serious failures to meet the reporting needs in each of the three categories mentioned above. For instance, there is a lack of:

- neighbourhood-level data and information in general;
- information on the local level of health, well-being, and quality of life;
- economic data and information collected and presented to conform with the needs of local governments;[50]
- comprehensive energy-use statistics collected and presented to conform with the needs of local jurisdictions (electricity and gas statistics from utilities are available, but data on other forms of energy, including liquid fuels and wood, are lacking);
- other resource-use statistics;
- data and information describing stress imposed on ecosystems (chemical, physical,

Table 4
Communities according to provinces and territories

Communities		
Region	**Number**	**Type**
QB	1,477	Municipalities (cities, towns, villages, townships and parishes, and counties)
ON	951	Statistics Canada census subdivisions (metropolitan government, regional/ district governments, cities, towns, villages, counties, and townships)
SK	943	13 cities, 146 towns, 376 villages, 290 rural municipalities, 105 Indian reserves, 13 northern hamlets
NF	705	310 incorporated (cities and towns), 396 unincorporated (local government communities and local improvement districts)
MB	293	Statistics Canada census subdivisions (cities, towns, villages, rural municipalities)
AB	325	16 cities, 109 towns, 122 villages, 4 summer villages, 30 counties, 22 municipal districts, 19 improvement districts, and 3 special areas
BC	150	Municipalities (regional districts, cities, towns, villages, municipal districts)
NB	117	6 cities, 27 towns, 84 villages (parishes and Indian reserves excluded)
PEI	89	1 city, 8 towns, 80 municipalities
NS	66	Municipalities (3 cities, 39 towns, and 24 rural municipalities [including villages and service areas] organized as 12 counties and 12 districts)
NWT	65	1 city, 5 towns, 1 village, 36 hamlets, and 23 unincorporated communities
YK	20	1 city, 3 towns, 4 villages, and 14 unincorporated communities

Source: Provincial and territorial government officials, and Higgins, 1986.

and biological) that, together with resource-use statistics, would allow assessment of the demands that a community places on its surrounding environment;[51]
- data and information describing compliance with existing laws and regulations; and
- data and information describing ecosystem conditions (e.g., street air quality, diversity, and the state of living things).

This list of shortcomings was identified in discussions with local government experts across Canada. It would take a vast effort, well beyond current means, to address them. There is a strong feeling, however, that there could be a significant improvement if fragmented information resources were co-ordinated.

A growing number of communities are forcing such co-ordination through state-of-environment assessments. But regular community-based assessments of economic activity are rare, as are attempts to come to grips with trends in community well-being and quality of life. However, much progress has been made through the Healthy Communities Movement. Assessments are being made that go well beyond earlier SOE reports. The most recent example is Toronto's 1993 *State of the City* report.

Discussion and Recommendation

Even though constitutional responsibility for local government and community development lies with the provinces, the federal government has an obligation to both provinces and communities because of:
- the need for a national database;
- the capability of the federal government to fulfil this need; and
- the cost savings to be realized through co-ordinated federal action.

In the Northwest Territories and Yukon, of course, there is a much greater degree of direct federal responsibility.

Statistics Canada is extremely well placed to respond to the need for a national database. It already gathers much data and information relevant to local government, and it enjoys an effective working relationship with provincial and municipal partners across the country. However, the federal government is constrained in what it can do because of the constitutional division of powers.

In the early 1970s, attempts by the federal government to address urban concerns in a co-ordinated way led to the creation of a federal Department of State for Urban Affairs. Federal-provincial jurisdictional disputes led to its demise within eight years.

The reality is, however, that for maximum benefits, national coverage is needed in reporting on progress toward sustainable development.

We recommend that the Government of Canada:

Identify a responsibility centre and provide it with the mandate to initiate discussions with provincial and municipal partners (including the national and provincial associations of municipalities) aimed at:

a) identifying and prioritizing specific data and information needs of community decision makers related to sustainable development; and

b) exploring the feasibility of establishing a national clearinghouse and other ways by which these needs might best be met.

Corporations and Corporate Groupings[52]

A focus on:
- Canada's corporate universe
- the evolution of corporate reporting
- what information and data are available
- leading edge, couch potato, or hostile avoider – commitment to disclosure varies among large corporations
- discussion and recommendations

Canada's Corporate Universe

Canada's corporate universe contains just over a million parts:
- roughly 900,000 for-profit businesses (including crown corporations);[53]
- about 140,000 not-for-profit voluntary organizations, churches, and trusts, of which half qualify for tax-exempt, charitable status;
- about 18,000 professional associations;
- about 7,000 co-operatives, of which 4,096 are non-financial co-operatives,[54] 2,807 are credit unions and caisse populaires,[55] and 11 are insurance co-operatives;[56]
- 1,227 hospitals;[57]
- 945 unions; and
- 249 universities, colleges, and community colleges.

Strictly speaking, government also functions as a "corporate entity." However, because of its special status as society's rule maker, it is considered separately.

In this report, we examine only the first category of decision makers – for-profit corporations.

The Evolution of Corporate Reporting

For the most part, corporate reporting is aimed at shareholders and investors, senior management, boards of directors, employees, and customers, and concentrates on the financial state of the company and on employee safety. Much of the financial reporting is required by law.

Responding to the concept of sustainable development, however, some leading members of the corporate world are expanding their reporting scope – and generally, they are doing so in two ways. In the first place, they are expanding the list of stakeholders targeted to receive their reports to include host communities. And secondly, they have broadened the value base that drives the reporting process to include ethical and environmental concerns. Their reports have been dealing with social, environmental, ethical, and procurement issues in addition to financial reporting.

Their motivation has stemmed from an expanding environmental and ethical awareness, and rising environmental standards in society at large. Moreover, they have come to recognize that economic benefits go hand in hand with environmental improvements, especially in the longer term and in the international competitive arena.

Corporate sustainable development reporting ranges from the creation of environmental mission statements or codes of practice; through elaborate performance or compliance monitoring; to anticipatory assessments of the environmental and social implications of activities, products, and services.

Ideally, reporting on any level is part of an overall corporate strategy for sustainability. Given the variety of corporate goals and objectives, there never will be one uniform way to monitor and assess corporate progress toward sustainable development.

A number of agencies have been instrumental in guiding companies. For example, the International Institute for Sustainable Development in Winnipeg has spearheaded

both development and synthesis of a variety of new ideas related to corporate environmental reporting.[58] The Canadian Institute of Chartered Accountants continues to explore whether "environmental auditing" can be formalized in a set of rules analogous to those governing financial auditing.[59] And EthicScan Canada has pioneered work on assessing and reporting corporate ethical performance.

What Information and Data Are Available?

Very few corporations in Canada have reporting procedures that go beyond a traditional prototype. We base that statement on research commissioned by the National Round Table's Task Force on Reporting.[60] The research showed that among:

Large corporations (more than 200 employees)

- in the order of 1 percent routinely monitor and assess some aspect of progress on sustainable development practices;
- fewer than 1 percent are committed to releasing an annual environmental report for external consumption;
- about 7 percent report environmental issues to their boards on a regular basis;

Medium-sized corporations (100-200 employees in the manufacturing sector, 50-200 otherwise)

- less that 0.1 percent routinely report progress on sustainable practices;

Small businesses and self-employed individuals

- it is a rare exception that any monitoring and assessing related to sustainable development practices occurs at all.[61]

We conclude that:

- in spite of documented evidence to the contrary, the majority of firms believe that there are prejudicial aspects to reporting publicly on sustainable development that outweigh potential benefits;
- few corporations have procedures in place to monitor and assess the impact of their operations on the receiving environment at any of the local, regional, or global levels – and if they do, still fewer publish their findings; and
- few corporations have procedures in place to monitor, assess, and report publicly on the overall contribution they make to the well-being of the local, regional, and national communities.

Leading Edge, Couch Potato, or Hostile Avoider: Disclosure Varies among Large Corporations

Large Canadian corporations generally display one of five levels of commitment to disclosing their record on sustainable development:[62]

Level 1
Leading edge – 1 percent of total
Early adapters or self-styled leadership companies and sectors that have reported at least once and are committed to doing so on a regular basis, typically annually;

Level 2
Vanguard of the rearguard – 2 percent of total
Cautious innovators that are preparing to undertake some aspects of state-of-environment reporting, parts of which may be made public;

Level 3
Corporate couch potatoes – 7 percent of total
Slow adapter companies that do not report except, perhaps, to an internal audience, yet

are watching the competition to see what transpires with those that are trying to report;

Level 4
Rearguard of the rearguard – 60 percent of total
Companies that are aware of reporting but, when asked why they do not report, identify a multitude of reasons – for example, that it is not practical, possible, or in their best interests to report;

Level 5
Hostile avoiders – 30 percent of total
Companies that are active resisters and oppose the very idea of reporting anything at all.

Discussion and Recommendations

Some Canadian corporations are excellent models of "leading edge" behaviour – which is heartening, given the growing evidence that so many of our international trading competitors are striving to apply the highest possible environmental and social standards, instead of the lowest possible, to such matters as waste and emissions, packaging, efficiency of resource use, auditing, and other areas of business.

To protect and improve Canada's competitive position, it is essential that corporate consumer regulation, and industry sustainable development standards – and especially reporting standards – be set to compare favourably to the highest in the world.

We recommend that the Government of Canada:

Make a commitment to having corporate and consumer standards set, in particular for reporting, that will compare favourably to the highest in the world.

Overall, we conclude that significant gaps exist between what ideally should be reported, what currently is practical, and what actually is being reported. Closing these gaps will take time. In the meantime, corporate sustainable development reporting should be nurtured but not regulated; encouraged but not standardized; reinforced but not necessarily legislated.

Corporations need to compare their actions with those of others – just as other decision makers do – and when they want to compare financial performance, there is plenty of information available. But, if they want to see how they compare in promoting sustainable development, except in a few cases, the broader comparative data and information that they need are not available. The exceptions are in those businesses where there are industry association programs such as the National Emission Reduction Master Plan, a voluntary program of the Canadian Chemical Producers Association.

There is, however, a special opportunity to develop a source of comparative and cumulative information, as well as to eliminate duplication of reporting at the community, corporate, regional, provincial, and national levels.

It will come with implementation of the National Pollutant Release Inventory (NPRI) that is proposed under section 16 of the Canadian Environmental Protection Act. The NPRI is a significant initiative, even though, within the context of everything that Environment Canada is doing, it does not represent a major undertaking.

Environment Canada is still working on details of the NPRI, and while it is doing so, Statistics Canada is developing a Waste and Pollutant Output Satellite Account as part of its work on modifying the System of National Accounts. The National Round

Table is concerned that the experience and expertise of both Environment Canada and Statistics Canada are not being co-ordinated in the best possible way. The result could well be duplication and, at worst, confusion in data gathering, as well as irritation on the part of companies faced with replying to yet more requests for information.

We recommend that the Government of Canada:

Make Statistics Canada jointly responsible with Environment Canada for development and implementation of the National Pollutant Release Inventory.

Management of the program should be aimed at collecting accurate and timely data that keeps to a minimum duplication with other efforts to gather data and information.

Up to this point, our examination of corporate decision makers has been focussed exclusively on for-profit corporations. When it comes to their not-for-profit cousins, the picture is much bleaker. Although we did not conduct extensive research, every indication points to most of them as lagging far behind for-profit corporations in their commitment to sustainable development reporting and practice.

With two exceptions, we are unaware of any voluntary association, union, university, or college that has implemented an ongoing sustainable development reporting process (internal or external) for itself as a corporate entity. The two exceptions are documented in a report on the initiatives of the Alberta Institute of Technology,[63] and in the statement of sustainable development aspects of internal operations contained in the 1992-93 annual report of the International Institute for Sustainable Development.

We recommend that the Government of Canada:

Take the necessary steps to encourage all corporate entities (including for-profit businesses, not-for-profit voluntary organizations, professional associations, co-operatives, hospitals, unions, universities, colleges, and community colleges) to:

- ***develop sustainable development codes of practice; and***
- ***implement practical reporting systems to facilitate monitoring and assessment of progress over time.***

The Federal Government[64]

A focus on:
- the dual role of government
- the size of government in Canada
- federal assets and purchases:
  what data and information are available
  discussion and recommendation
- the impact of federal actions:
  what data and information are available
  discussion and recommendations
- assessing progress in all of Canada:
  discussion and recommendation

The Dual Role of Government

When it comes to reporting, the federal government has a dual role. One is to focus on the country; the other is to focus on itself. In its first role, the government is responsible for establishing reporting procedures that allow monitoring and assessment of the activities and well-being of Canada's people and ecosystems. This serves its citizens and addresses the decision-making needs of Parliament.

In its other role, the government reports to the electorate on its performance as a corporate entity. As with any corporation,

the government employs people, provides services, stresses the ecosystem – for instance by contaminating air, water, and land, and by using resources – and can take action to reduce stress on the ecosystem that is caused both by it and by others. In this second role, the government is in a special and too rarely exercised position of potential leadership among decision makers.

The Size of Government in Canada

Statistics Canada listed 97 federal government departments in fiscal 1992-93, and the 1991 census counted 443,500 employees.[65] Statistics Canada also identified 265 provincial and territorial departments and agencies employing 311,560 people, and 7,524 local governments employing 354,130 people. In total, government employees made up 7.5 percent of Canada's labour force.

The federal government is the largest commercial property holder in Canada, owning or leasing 25 million square metres of office space. The federal inventory of buildings and facilities lists more than 50,000 items including office buildings, laboratories, parks, and military bases.

Federal Assets and Purchases: What Data and Information Are Available?

Parliament is responsible for holding the executive branch (the federal government as run by a political party) accountable for its actions. Control of expenditures and management practices is achieved under a three-part process that includes:

- the budget;
- main and supplementary estimates; and
- the Public Accounts of Canada, which are published annually and are examined and signed by the Auditor General – and often carry his critical comments.

The progress of financial transactions is reported at each stage. However, tracking them through each stage is another matter. Often it is a formidable task that can daunt even the experienced. Tracking and valuing real property and capital assets poses additional difficulties.[66]

The Treasury Board Secretariat maintains a Directory of Federal Real Properties, which it is computerizing under its Area Screening Canada (ASC) program. When this task is completed in 1993-94, there will be a computerized inventory, based on 45 geographic areas, of every property the government rents or owns.

For some assets, such as warships, the parliament buildings, crown wilderness lands, and forests, no evaluation procedures have been established. And where there are government properties with identifiable market values, no attempt is made to track changes in what they are worth as markets themselves change. Most real property is managed by the Department of Public Works and Government Services. Management of the remainder is assigned according to program responsibilities to various departments and agencies, such as Agriculture and Agrifood Canada, the Royal Canadian Mounted Police (RCMP), the Department of National Defence, Correctional Services, the Department of Foreign Affairs, and Transport Canada.

Although each department is responsible for maintaining an inventory of all its other capital assets – such as laboratories, libraries, licences to technology, vehicles, royalty rights, desks, and computers – there is no mechanism to consolidate this record across the federal government. Furthermore, all capital goods are written off on purchase (as an operating expense) and there is no tracking of depreciated value over time as there is in private industry.

The Auditor General has voiced his concern over these practices and, as a result, the Office of the Comptroller General is

examining how to introduce capital depreciation and valuation into federal management practices. However, no changes are expected for two years.

Because of current practices, the federal government cannot:

- track the inventory and value of real property and other capital assets in any comprehensive way; or
- provide a consolidated inventory of real property and other capital assets that have no assignable value.

Federal Assets and Purchases: Discussion and Recommendation

Shortcomings in the federal system of cataloguing and tracking the value of government assets introduce a limit to institutional memory. They stand as an impediment to monitoring the record of the government over the long term. And they impede the government's ability to assess sustainability:

- from a financial perspective; or
- by completing a full analysis of the "state" of its assets from an environmental perspective; or
- by completing a full analysis of the stress that its assets, and the way in which they are used, are imposing on the ecosystem.

The federal financial management and reporting system is complex, and the way in which it is reported is far from user-friendly. In fact, the form and complexity of the reporting process is a significant barrier to a greater understanding of government in this country.

The reporting system should be much more transparent than it is, and it should engender a much greater sense of value than it does.

We are aware that a number of departmental initiatives have been taken to encourage "environmentally smart" activities – in particular the three Rs: reduce, reuse, and recycle. In addition, the Speaker has undertaken initiatives to make Parliament itself function in a more environmentally sensitive way. And the Office of Environmental Stewardship is examining federal procurement to see how environmental criteria can be applied to purchases.[67]

However, cross-governmental strategic action has not occurred, even though it has been recommended. In the late 1980s, as a result of recommendations from the Nielsen Task Force, the federal government committed itself to developing the "Canadian Annual Procurement Strategy" (CAPS). The strategy was aimed at a better integrating of socioeconomic and environmental priorities into Cabinet and departmental purchasing decisions. It also was intended to give business and the general public a clearer picture of government purchasing priorities. Unfortunately, the main purchasing departments – the departments of National Defence, Transport, and Public Works and Government Services – had operational needs that were not met by CAPS and the strategy is now dormant.

A less ambitious "Short Range Planning System" has been developed to encourage interdepartmental liaison on procurement, and it is subjecting major procurement initiatives to standard environmental assessment practices. However, no government-wide procurement policy and tracking system such as CAPS is contemplated and it is important that there should be one.

We recommend that Treasury Board:

Re-assign priority to efforts that will lead to the development and implementation of a government-wide procurement strategy and related tracking system that:

a) reflects the principles of sustainable development;
b) provides the Cabinet, Parliament, and the public with a three- to five-year perspective of government procurement plans; and
c) includes a reporting system that effectively compares actions with intentions.

The Impact of Federal Actions: What Data and Information Are Available?

We are unaware of any departmental or overall government attempt to develop and implement a long-term reporting system for sustainable development similar to what is emerging in the for-profit corporate world.

Estimates compiled in the mid-1980s by the Major Surveys Team of the Nielsen Task Force indicated that the federal government spends three quarters of a billion dollars annually, and employs more than 10,000 people, in collecting basic information about Canada, its people, its economy, and the ecosystem. The provinces spend a further $125 million to $150 million a year.

It was clear then, as it is today, that there are great variations in the priorities and approaches that are adopted in collecting and analysing data and information. They depend on whether the focus is on the activities and well-being of people, economic trends, natural resources, specific industries, or the state of the ecosystem. The result is a highly fragmented federal information system that provides inadequate support for the new agenda implicit in sustainable development.

Nevertheless, there are initiatives being taken within the federal system that are showing great progress, even though they are not fully integrated. Of particular note are:

- advances reflected in the 1991 *State of Canada's Environment*, published by Environment Canada, and in *Human Activity and the Environment*, published by Statistics Canada;
- progress made by Environment Canada in integrating economic and environmental concerns in the development of a national set of environmental indicators;
- the ongoing growth and development of Canada's system of monitoring ecosystem conditions, including identification of a key list of environmental indicators, which has been spearheaded by Environment Canada's State-of-Environment Reporting Service – which, in turn, has enjoyed the co-operation of Statistics Canada and a variety of other federal and provincial departments;
- Forestry Canada's annual review of the state of Canada's forests, which is presented to Parliament – however, the last review published was for 1991;
- ongoing modifications to the System of National Accounts undertaken by Statistics Canada, in co-operation with the United Nations, OECD, and others that will allow environmental concerns to be dealt with more effectively;
- ongoing efforts by Statistics Canada to identify and compile a variety of social indicators through its General Social Surveys;
- the evolution of a new system of health information in a co-operative venture of Statistics Canada and the National Health Information Council, which is taking place within the Canadian Centre for Health Information, located within Statistics Canada; and
- Health Canada's increasing efforts to assess the link between human health and environmental conditions.[68]

On a global scale, Canada is part of a world community in which international agreements are of growing importance. They cover a broad range of topics, including trade and regulation of certain activities such as fishing and whaling. Moreover, at home, there is a great deal of provincial and federal legislation that

has implications for Canada's international competitive position.

With the publication of *Canada's Green Plan*, the federal government committed itself to undertaking a comprehensive review of the environmental impacts that flow from implementing existing statutes, policies, programs, and regulations. It also committed itself to proposing modifications wherever necessary. The initial phase of this review was scheduled to take place between 1991 and 1996. It has stalled.

No one federal department has been given the responsibility of regularly reviewing international, national, and provincial legislation and regulations as they relate to sustainable development. The goal of such reviews should be to assess and report on how they impact upon Canada's trade position, what implications they carry with respect to overall prosperity, and how they affect the integrity of the ecosystem both within Canada and beyond.

The Impact of Federal Actions: Discussion and Recommendations

The lack of a system for reporting on its own performance in advancing sustainable development represents a serious inadequacy in federal management. On the other hand, if the federal government were to implement such a system, it would provide a major opportunity to demonstrate commitment to the idea of sustainable development and to offer leadership in Canada through example.

An essential step is to establish an office invested with reporting responsibilities. To be effective, it will have to function independently, link with all parts of the federal system, and be able to work successfully with each of them. It cannot, therefore, be assigned to an existing department such as Environment Canada, Industry Canada, or Revenue Canada.

We have identified five alternative approaches that have been used to deal with policy issues that cut across all departments. The approach to be used will require careful consideration and the National Round Table is continuing its examination of the various advantages and disadvantages.

Historically, cross-departmental integration has been achieved by:

- informal strategic alliances;
- interdepartmental memorandums of understanding (e.g., between Environment Canada and Statistics Canada or between Environment Canada and Industry Canada);
- creating ministries of state (such as Urban Affairs, Social Development, Economic and Regional Development, or Science);
- creating a branch within the Treasury Board with special integrative functions and, to make sure there is a policy link with Cabinet, a parallel secretariat within the Privy Council Office; and
- appointing a commissioner who reports either directly to Parliament (as does the Commissioner of Official Languages), or to a minister (as does the Commissioner of the RCMP, who reports directly to the Solicitor General).

In 1987, New Zealand followed the last of these options in creating a Parliamentary Commissioner for the Environment who is charged with providing an independent source of advice to Parliament on environmental matters. Its commissioner is free from government policy constraints and government directives, and acts as an independent watchdog over New Zealand's approach to issues that affect the environment.

Each of the various options has strengths and weaknesses and a combination might be best. What is most important is that a commitment be made by the Government of Canada to create the kind of office we are suggesting.

We recommend that the Government of Canada:

Establish a capability for:

a) assessing and reporting annually on progress toward sustainable development within the federal government as a corporate entity; and

***b) reviewing the environmental implications of actions taken as a result of existing statutes, policies, programs, and regulations – as promised in* Canada's Green Plan.**

Exactly what shape this office should take, and where it should be located – within or at arm's length to the federal government – requires further assessment. What is most important is that it be clearly assigned this responsibility and given authority for discharging it. Further, the office must be independent and able to link effectively to, and work with, all parts of the federal system. It cannot, therefore, be embedded within any existing department.

Reporting on its own performance is only half the battle, however. The federal government also needs to make a commitment to bringing its performance into line with sustainable development principles.

There is no overall strategic policy that has resulted in such a commitment. The National Round Table has concluded that without such a policy, little will change within the federal system.

We recommend that the Government of Canada:

Develop a policy statement that entrenches a government-wide commitment to sustainable development in the mandates and reporting responsibilities of federal departments, agencies, and crown corporations.

It is essential that this policy make individual departments responsible and accountable for ensuring that their policies, programs, and budgets encourage and support activities that are economically and ecologically sustainable, both in the short and longer terms.

Assessing Progress in All of Canada: Discussion and Recommendation

At present, there are no means by which progress toward sustainable development in all of Canada can be reviewed on a periodic basis. Moreover, because of shared constitutional responsibility, there is little hope that such reviews can be established without co-operation from both federal and provincial governments. Consequently, establishing a capability will have to be a collaborative effort from the outset.

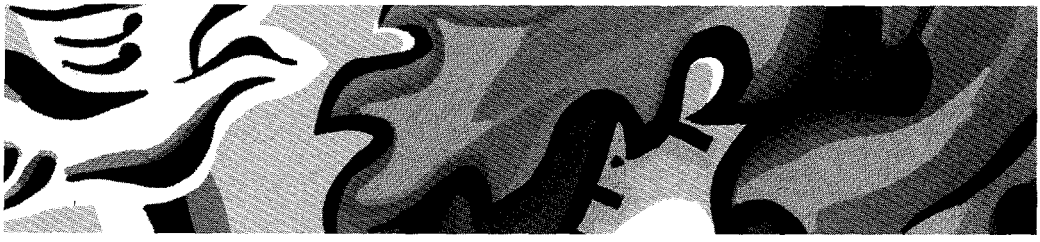
It is essential, however, that collaboration extend beyond the two senior levels of govern-ment to include all sectors of society – to include what often is referred to as "civil society." A broad-based involvement will not only ensure that a high level of experience and expertise is brought to bear, it also will generate much wider allegiance and support.

We recommend that the Government of Canada:

Initiate discussions with provincial and territorial governments and other stakeholders aimed at:

a) designing and establishing a capability for assessing and reporting every five years on progress toward sustainable development for Canada as a whole; and

b) providing an assessment every five years of domestic legislation and regulations (provincial, interprovincial, and federal), as well as of international treaties and conventions, that are relevant to sustainable development and that impact on Canada's trade position, economic prosperity, and ecosystem integrity.



Epilogue

Commitment and Trust: Making Reporting on Sustainable Development a Reality

As part of the research for this project, a small survey of households in the Victoria area was undertaken.[69] On reading it, we were struck by the vehemence of the demand for credible environmental information, the general lack of trust in the "green" claims of manufacturers, and the frustration with the media for de-emphasizing environmental issues at a time when interest and concern are so high.

The expression of views may be a little more strident than usual, but the tenor of responses certainly is in keeping with other surveys, and with observations of the National Round Table itself. The responses also can be seen within the context of the cynicism with which many of the electorate regard elected officials and their declarations of concern for sustainable development.

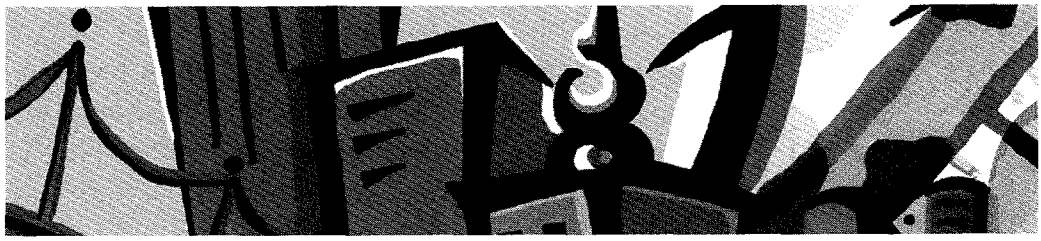
Vehemence, lack of trust, frustration, and cynicism are a potent mixture and an indication that people are impatient with the slow rate at which sustainable development issues are being addressed. If there were to be an unmistakable commitment to sustainable development by decision makers, and especially by the Prime Minister and the Government of Canada, much could be done to alleviate these concerns and generate the trust in leadership that seems so lacking.

Entrenching mandates and responsibilities for reporting openly on progress toward sustainable development would go a long way toward establishing that kind of commitment. And the remarkable bridging characteristics of sustainable development would encourage collaborative approaches in implementing those mandates that would strengthen our social fabric.

Bringing such systems into being will involve:

- actions that appeal to the enlightened self-interest of all decision makers, whether they are acting as individuals or as members of households, communities, corporations, regions, provinces, or the country as a whole;
- actions that respond to the public's right to know, such as establishing the new National Pollutant Release Inventory; and
- actions that nourish values based on care and respect for both people and the ecosystem.

The National Round Table urges an early start.



Introduction

The Colloquium on Sustainable Development Reporting was convened by the National Round Table on the Environment and the Economy, in London, Ontario, November 25-26, 1993. Presented here are the three background papers commissioned for the colloquium:

- "Approaches to Reporting on Ecosystem Health," by David Rapport;
- "Commonplaces and Heresies about the Human-Ecosystem Interface," by Ted Schrecker; and
- "Approaches to Reporting on Human Well-Being," by Susan Holtz.

Each paper is followed by a section containing the proceedings of the colloquium. It includes the author's presentation, a synopsis of responses, a formal critique of the paper, and a brief report of the open discussion that followed. No attempt is made at synthesis, and speakers, other than those who contributed papers or formal critiques, are not named for the reason that, as debate criss-crossed the floor, attributing each comment would have required either a format or a constant litany of "he said" and "she said," which would have impeded the flow of ideas across the written page.

An overall synthesis of the discussion at the colloquium is presented in a concluding paper by Ted Schrecker entitled "Synthesis of Discussion."

semi-enclosed seas (e.g., the Mediterranean and Baltic) and major bays and estuaries (e.g., Chesapeake Bay).

As industrialization intensifies, air becomes the next resource to be marginalized. At the early stages of industrialization, air pollution is localized – confined to the immediate environs of the factory stack. These local impacts may, however, be of devastating proportions – for example, the "moonscape" produced by the smelters at Sudbury. Although there has been a remarkable and largely successful effort to stem these local blights on the landscape, the "greening" of industry is largely a Western phenomenon, having little impact on the worst abuses of industrial production that predominate in much of the developing world (e.g., China and eastern Europe).

As countries reach some intermediate stage of development (e.g., Mexico and Taiwan), diffuse sources of air pollution from the automobile and other vehicles exact a toll on regional air quality. In urban areas, the daily cycle of "dirty air" is well documented – two of the best-known examples being in Los Angeles and Mexico City.

From an ecosystem health perspective, however, it is perhaps not the local effects, as visible and obvious as they are, that pose the greatest risk. More likely it is the global effects of a changing atmosphere, for example, depletion of the protective ozone layer and increased concentrations of so-called "greenhouse" gases. The local "hot spots" of severe air pollution might in retrospect be seen as early-warning indicators of a global marginalization of air resources.

In the later stages of economic development, marginalization of the environment tends to shift from the developed to developing countries. For example, the Japanese protect their remaining forests and trees (the cherry tree is particularly sacred), while harvesting without much restraint the large tracts of Southeast Asian forests; North Americans are seeking agreements with developing countries for dumping industrial wastes that are either too costly to dump or prohibited from being dumped at home; and industries are migrating from areas with restrictive environmental legislation to areas without such restrictions (so-called pollution havens).

Questions of Scale

Given the broad patterns sketched above, the question of appropriate scale for monitoring progress toward sustainable development needs to be addressed. Clearly, the broad patterns suggest the proper scale is at least the large regional landscape, at the level of ecoregions or ecozones, or alternatively major drainage basins. International discussions on sustainable development and the various accords that support that goal are formulated on a national basis. But nations may not be the proper units for assessing progress toward sustainable development, since national borders seldom respect ecological ones. From the ecosystem health perspective, it is clearly possible to functionally define smaller units (e.g., the Great Lakes basin, the boreal forests, and the Prairies) and evaluate these regions with respect to criteria for ecosystem health – reflecting both the underlying organizational aspects of ecosystems and societal values. The size of the appropriate geographical units could vary from the large-scale ecosystem level to landscapes, nations, and the entire biosphere.

When it comes to the landscape level, there are questions concerning the mosaic of ecosystems with differing degrees of pressure from human activity. Can a landscape be judged healthy and sustainable even though it contains elements that are clearly overexploited?

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- actions that nourish values based on care and respect for both people and the ecosystem.

The National Round Table urges an early start.

Endnotes – Part I

1. Modified from Robinson et al., 1990; see Hodge, 1995.
2. Variously labelled sustainable equitable development, environmentally sustainable economic development, environmentally sustainable socioeconomic development, ecologically sustainable development, and ecologically sustainable economic development.
3. WCED, 1987, 8.
4. Daly, 1989, 4.
5. Hodge, 1995.
6. In the U.S., the Council of Environmental Quality (CEQ) was established in 1970 in the President's Office by the National Environmental Policy Act (NEPA). Under NEPA, the President is required to file with the Congress an annual Environmental Quality Report setting forth the status and conditions of the nation's environment. The report was to trace current environmental trends, assess the adequacy of natural resources to fulfil human and economic needs, review and assess activities affecting the environment, and suggest ways of remedying program deficiencies. The CEQ was established under President Nixon and was continued through the Ford, Carter, Reagan, and Bush administrations. Staff and financial resources were stripped from the CEQ in the early 1980s by the Reagan administration and, since 1984, the annual reporting requirement has not been met consistently. By 1990, the Bush administration was considering re-injection of resources into the CEQ but the momentum of the first decade of CEQ activities was never regained. The Clinton administration is maintaining the CEQ but at reduced levels of resources and staffing.
7. Canada has placed first or second in the Human Development Index (HDI) rating since inception of the index in 1990. The HDI includes three components: (1) longevity (life expectancy at birth); (2) knowledge (adult literacy and mean years of schooling); and (3) income (income modified to allow for diminishing returns). See UNDP, 1993.
8. The International Society for Ecological Economics (ISEE) and their journal, *Ecological Economics.*
9. For example, see Evans and Stoddart, 1990, and NTFHI, 1991.
10. Environment Canada, 1991.
11. Gosselin et al., 1991.
12. Ruitenbeek, 1991; Victor et al., 1991; Potvin, 1991.
13. Canada, 1991.
14. The Business Council on National Issues, Canadian Bankers Association, Canadian Chamber of Commerce, Canadian Chemical Producers Association, Canadian Electrical Association, Canadian Institute of Chartered Accountants, Canadian Manufacturers Association, Canadian Petroleum Association, Conference Board of Canada, Insurance Bureau of Canada, Mining Association of Canada, and professional engineers associations in a number of provinces, have all been active in this area.
15. Schrecker et al., 1993.
16. Hodge, 1995.
17. Examples include technical data and information provided by Environment Canada's Environmental Choice Program, periodicals such as *Protect Yourself,* published by Quebec's Bureau de la protection du consommateur, or *Consumer Reports* or any one of a large number of books aimed at providing advice to consumers.
18. Hodge, 1995. This set was developed from 18 contributions that in some way address goals and objectives for sustainable development.
19. Rawls, 1987.
20. Hodge (1995) proposes this structure on the basis of the value set reflected in Table 1, the results of a review of 30 theoretical models that address the human-ecosystem interface, and over 200 state-of-environment reports from around the world.
21. Hodge, 1995.
22. Hodge, 1995.
23. Hodge, 1995.
24. Jackson, 1992.
25. Department of the Secretary of State, 1990.
26. Brown, 1991, and see discussion in Bregha et al., 1993.
27. Cassils, 1993.
28. Hodge, 1991, 16.
29. Lalonde, 1974.
30. IUCN et al., 1991.
31. UNDP, 1993, 1.
32. UNDP, 1993, 1 and 2.
33. NTFHI, 1991, Preface, 2.
34. For example, see Hancock, 1985.
35. Gosselin et al., 1991.
36. NTFHI, 1991.
37. Evans and Stoddart, 1990.
38. CMA, 1991, 39.
39. OECD, 1991, 8.
40. Preliminary results are reported in Environment Canada, 1991.
41. Results are reported in Gosselin et al., 1991.
42. Potvin, 1991.
43. Marbek, 1990; Western Environmental and Social Trends, Inc., 1991 (draft).
44. Hancock and The October Group, 1993, provided a starting point for this section.
45. Statistics Canada, 1992.

46. Statistics Canada, 1992.

47. Hancock and The October Group, 1993, provided a starting point for this section.

48. Daly and Cobb, 1989, 49 and 172.

49. Natural, modified, cultivated and built elements of the ecosystem (see IUCN, 1991, 34) can be identified and need attention. Communities are usually equipped to monitor and assess the state of the built ecosystem but have much less experience at dealing with the other components.

50. This conclusion was recently reinforced by work aimed at both community development and broader provincial development undertaken by the British Columbia Round Table on the Environment and the Economy. See BCRTEE, 1993.

51. Work pioneered by William Rees at the University of British Columbia is leading to the definition of the "ecological footprint" of communities – an estimate of the land area outside the jurisdiction implicated by activities within the jurisdiction.

52. Nitkin and Powell, 1993, provided a starting point for this section.

53. In 1992, Statistics Canada reported 886,964 "establishments"; in 1990, 934,650 businesses were registered. In 1992, 14,317 business bankruptcies were reported. "Small businesses," those with fewer than 50 employees, account for 97 percent of all businesses. However, the small business shares of total business sales, profits, and assets are 26 percent, 51 percent, and 14 percent respectively (1988).

54. Figures are for 1989. Of these 4,096 non-financial co-operatives, 900 had an agriculture base, represented over 510,000 producers, and accounted for 71 percent of the $15.3 billion total revenues. More than 3.2 million members were reported in 1989.

55. In 1989, credit unions and caisses populaires achieved membership of nearly 9.2 million, or 35 percent of the population.

56. These 11 insurance co-operatives reported nine million policy holders in 1989.

57. These hospitals directly account for about 35 percent of Canada's total health care costs, which in 1992 stood at $48 billion.

58. See IISD et al., 1992, and Deloitte Touche Tohmatsu International et al., 1993.

59. See CICA, 1992.

60. Nitkin and Powell, 1993.

61. If small business employment and self-employed individuals (1.8 million in 1992) are combined, they make up roughly half of all those employed in the private sector in Canada.

62. Nitkin and Powell, 1993.

63. The Northern Alberta Institute of Technology (NAIT) has created a "President's Advisory Committee Monitoring Our Responsibility to the Environment." Their 1990 report identified over a dozen issues ranging from traditional health and safety considerations through hazardous waste disposal. Recommendations were made regarding awareness, facilities management, food services, paper products, newsprint wastage, and pop can disposal.

64. Bregha et al. provided a starting point for this section.

65. Note that this figure is different from the 227,415 person-years authorized in the 1990-91 Main Estimates, because it includes all individuals employed by the federal government, whether full-time, part-time, or on contract. Canada's Green Plan (Canada, 1990) noted that the federal government, together with crown corporations, employs over 585,000 people.

66. This same issue emerges in debates regarding the adequacy of the System of National Accounts in tracking the overall state of "natural resources."

67. The Office of Environmental Stewardship estimates that total federal, provincial, and municipal government procurement of goods and services exceeds $70 billion per year. Annual federal procurement is about $8 billion. A crude estimate is that product stewardship considerations could influence about $5 billion worth of federal procurement.

68. See especially Health and Welfare's 1991 publication, *A Vital Link*, and the Great Lakes Health Affects Program now in its fourth year.

69. Hancock and The October Group, 1993.

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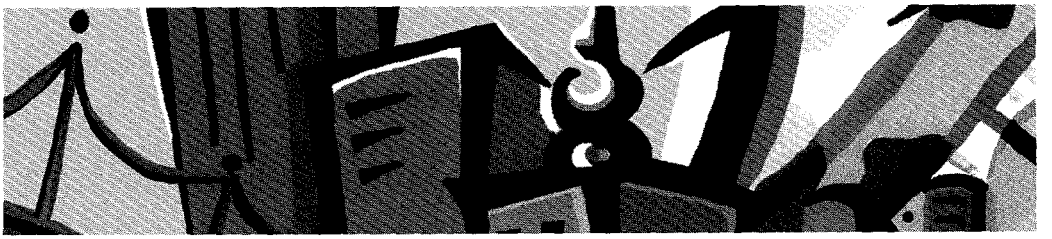
Part II

Colloquium on Sustainable Development Reporting



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An overall synthesis of the discussion at the colloquium is presented in a concluding paper by Ted Schrecker entitled "Synthesis of Discussion."

Ecosystem, Interaction, People, Synthesis

The focus of Prof. Rapport's paper was the first of the four indicator domains identified by the National Round Table as providing the basis for a system of reporting progress on sustainable development in Canada. This domain deals with assessing the integrity, health, or well-being of individual ecosystems.

Approaches to Reporting on Ecosystem Health

By David Rapport, Professor
Department of Biology, University of Ottawa

The Concept of Ecosystem Health

Economic development has radically transformed and materially enriched, beyond measure, the life of the privileged 20 percent of humankind. But for the 80 percent that lives at or near subsistence levels, economic development has had little effect – it may have even impoverished them further. However, where there is gain there is cost, and for both rich and poor nations alike, unprecedented degradation of the environment has accompanied economic development. This degradation is now exacting a heavy toll. Preventing that toll from rising further and completely sapping the "life blood" of living systems may prove to be the ultimate challenge for the survival of humankind.

In a bygone era, when human populations were only a fraction of those today, and the technological capacity for inflicting substantial damage to natural systems was limited to local scales, simple assumptions that detached economic life from the underlying productive capacity of the environment were not overly violated. Today, although economic texts still proclaim that the circular flow of money and goods feeds only upon itself, it is well known that economic gain has been at the expense of much of the accumulated stock of ecological capital. In drawing down that capital, society has accumulated an enormous environmental debt.

The size of the environmental debt is being measured in terms of the heightened rates of species extinction – estimated at 40,000 per year (mainly insects and invertebrates), the disappearance of whole ecosystems, the transformation of productive drylands to deserts, losses in agricultural fertility, and so forth. It may also be measured in human misery, where there are acute shortages of fuel and food, and increased frequencies of famines, floods, catastrophic epidemics, and wars.

The global prospect facing humankind is one of considerable risk to the survival of our own species. In view of these ominous events and dire predictions, the search for "sustainable development" sounds a more optimistic note, and an intriguing one.

Ecologically Sustainable Development

What is meant by "sustainable development"? Clearly, it cannot be taken in the conventional sense of economics – that is, expansion of the physical structure of the built environment, accompanied by an ever-expanding population; this kind of development cannot be sustained, at least not indefinitely. The finite resources of the earth, its limited capacity to receive wastes, and already overstressed ecosystems require that any sustainable future be designed on an altogether different basis.

It is this different basis that provides a legitimate use of the term "sustainable development," where the term "development" here is interpreted to mean "the capacity (of an ecosystem) to respond positively to change and opportunity" or "maintenance of the dynamic capacity to respond adaptively" (Golley 1990, 16). In this context, the key property to be sustained is the capability of natural systems to maintain their dynamic capacity to respond adaptively to perturbations and surprise. This requires that primary attention be given to the goal of preservation, maintenance, and enhancement of the health of the earth's large-scale ecosystems. Achieving these goals calls for development of an integrated science, involving important aspects of the natural sciences, social sciences, and health sciences.

In Figure 1, the conceptual basis for an integrated science of ecosystem health is portrayed. Ecosystem health is here defined, not only in conventional ecological terms, but also in socioeconomic and human health terms. Humans and their social and physical infrastructure are deemed part of and not separable from the ecosystem. These components are interactive. Interpreting this figure might be easier in the context of a particular example.

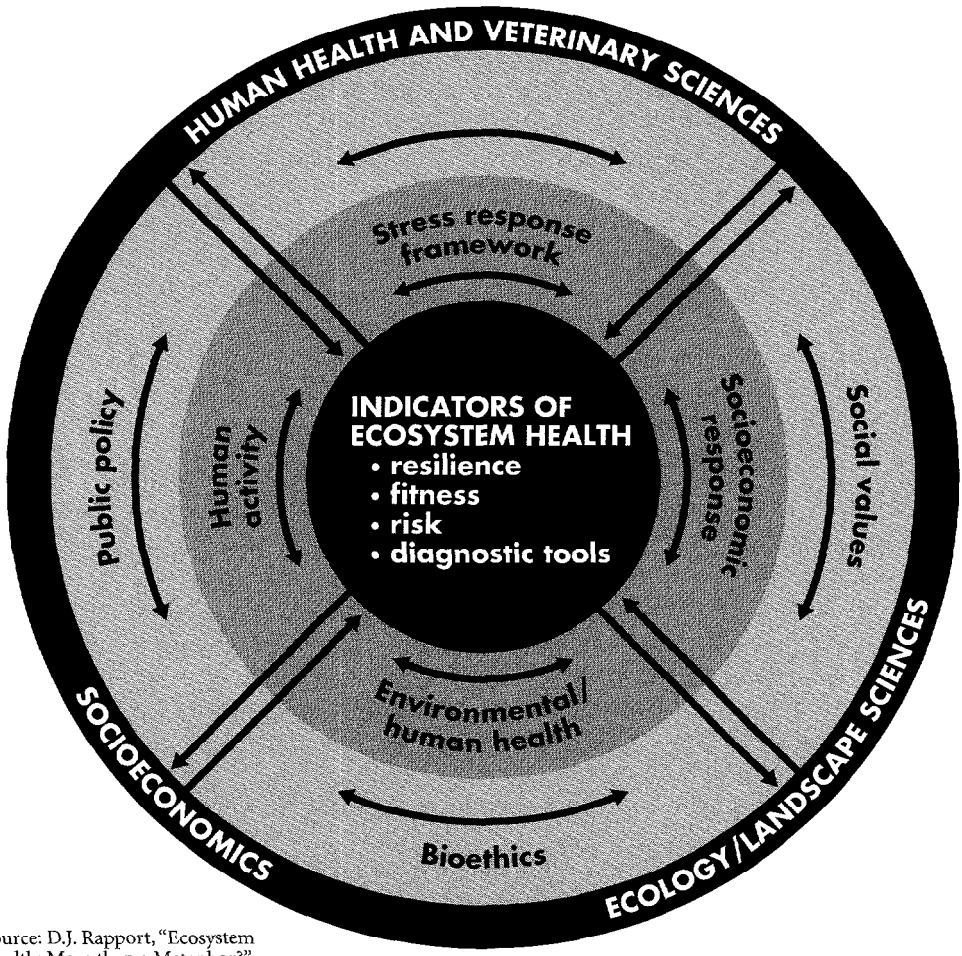
A Transdisciplinary Perspective

Take the case of Canadian agriculture: in recent evaluations of agroecosystems, diametrically opposite conclusions were reached reflecting two partial perspectives. In a preface to a 1989 policy review of agricultural activities in Canada, the Honourable Don Mazankowski, Minister of Agriculture, noted that "we have a sound agri-food industry that is doing a good job. Let us grow together. Let us build on our successes . . ." (Agriculture Canada 1989). This assessment of Canadian agriculture was based largely on gains in productivity and alleged improvements in efficiency. While the report acknowledged the need for structural adjustments and environmental sustainability, the overriding tone of the policy review was that the agri-food industry should focus on becoming more competitive and profitable.

In a 1992 report, the Science Council of Canada (1992) drew a very different picture. While acknowledging productivity gains, the Council underscored the serious "vulnerability of a system driven by agricultural policies that emphasize increased production at the expense of environmental considerations." If one were to examine agricultural activities from a public health perspective, yet another vision of the realities in agriculture would be revealed. The rate of disabling injuries among farm workers is even higher than that among construction workers (Schwing and Albers 1980).

The apparent inconsistencies in these assessments are derived from the fact that each is based on a limited view of what constitutes agroecosystem health. Clearly, ecosystem health comprises biophysical integrity, socioeconomic well-being, and human health. Each of these domains has its own set of indicators, and a comprehensive analysis of health in one

Figure 1
A transdisciplinary framework for assessing ecosystem health



Source: D.J. Rapport, "Ecosystem Health: More than a Metaphor?" Environmental Values, 1994.

domain may in the short run be supported at the cost of health in another; over time the system becomes unsustainable if health in any domain is compromised.

If ecosystem health is to provide the measure of sustainability, it needs careful definition. Does the metaphor drawn from the health sciences have any practical significance for the environmental sciences? Some critics still claim the metaphor is baseless owing to the enormous difference between an organism and an ecosystem (Suter 1993; Kelly and Harwell 1989). Yet, who would deny that the "health" of many regional ecosystems has been compromised?

Obviously, to dismiss the notion of ecosystem health on the grounds that the metaphor cannot be taken literally is to fundamentally misunderstand the purpose and value of the use of metaphor in science (Rapoport 1983). While ecosystems are not organisms nor "superorganisms," they are nonetheless highly organized systems that have often become degraded through the influences of human activity. This results in a reduction in "ecosystem services." To prevent such damage and alleviate it where it already has occurred is one of the primary goals of the transdisciplinary approach of ecosystem health and medicine. What is sought is development and elaboration of methods for diagnosis, prognosis, and treatment of the ecosystem under stress. The goal of this integrated science is to identify methods of preventative ecosystem care, so that interventions can be made before ecosystem resilience is compromised and effective treatments become more problematic and entail considerably higher costs and risks (Maini 1992).

While there is no generally accepted definition of ecosystem health, there is a variety of proposed definitions – most of which show a great deal of congruence (Rapport 1989a, 1992a; Costanza 1992; Calow 1992). Further, there is a substantial literature developing around a related concept, namely that of "ecosystem integrity" – which, if not identical to the concept of health, is certainly largely consistent with it (Karr 1991; Woodley et al. 1993). To mirror the definition of human health given by the World Health Organization, ecosystem health may be said to be a "resource," enabling ecosystems to adapt to changing conditions and evolve (University of Guelph 1993).

Ecosystem Health as the Bottom Line

"Sustainable development," as a code word for "the capacity to respond positively to change" (Golley 1990), implies that a precondition for achieving this is the maintenance of ecosystem health. The supposition is that ecosystems that are healthy are better buffered against perturbations and are more likely to recover from surprise events. Integrative indicators of ecosystem health may be found in two key attributes, both of which were compromised, historically, in the course of economic development. One of these is the supply of ecosystem services (Cairns, Jr. and Pratt 1995); the other is the preservation of management options (Whitford 1995).

The Supply of Ecosystem Services

Ecosystem services is an amorphous term – referring to all aspects of ecosystems that have value, although they are not necessarily measured in economic terms. These include, importantly, productivity (both primary and secondary); biodiversity (at all levels, i.e., genetic, biotic, habitat); water quality; aesthetics; persistence; and resilience.

Under pressures from conventional economic development, these services have generally become compromised with both their quantity and quality diminishing. This occurs at a variety of scales – locally, regionally, and globally. Such declines in ecosystem services can prove catastrophic for the human community directly dependent on such services. A recent example is the collapse of the east coast ground fishery in Canada, with its high economic and social costs to the fishing villages and fish-processing industries that are the mainstay of the coastal economies.

Loss of Management Options

A second integrative measure of loss of ecosystem health is a decrease in management options. The impact of conventional economic development on ecosystems has in many cases resulted in a decline in potential uses of many kinds of natural resource systems. Regier and Baskerville (1986), for example, refer to the historical sequence of qualitative and quantitative resource changes after decades of cultural stress in the Great Lakes fishery and in the New Brunswick forest under exploitative development. In both systems, overexploitation of preferred species has entrained a process of "hygrading" – harvesting less preferred species. Management options for the alternative use of the ecosystem (e.g., recreation and commercial harvesting) have been sharply curtailed. Similar losses of management options have occurred with respect to overgrazing by cattle on western drylands. In the case of impaired range lands, the carrying capacity of much of the land was reduced, and in extreme cases, where the ecosystem was transformed from arid grasslands to desert, the option of using the ecosystem for grain or domestic herds was almost totally eliminated. Thus the loss of ecosystem health and integrity also invariably implies a significant loss in the potential uses of the system.

The loss of ecosystem services and management options reflects deterioration in ecosystem health. Here the metaphor with human health is apt. Often accompanying illness is physical or mental impairment or both – resulting in fewer capabilities for coping. As a terminal illness progresses, generally speaking, the rehabilitative options decline until the final stages of the illness, when options for rehabilitation disappear and only palliative treatments can be given.

Economic Development and Environmental Change

A clear understanding of the general processes that link economic activity to ecosystem transformation and vice versa is essential for formulating a comprehensive monitoring framework for indicators of sustainable development.

The key question becomes: what has been the associated spectrum of human activities that has led progressively to the decline of the viability of the earth's major ecosystems? Which activities have been directly associated with certain types of ecosystem damage? It is now possible to sketch out, in general terms, at least, the sequence of events as environments become degraded under the pressure of economic and demographic change. Validating these general patterns might provide a basis for selecting a group of indicators that could be used to assess progress toward achieving "sustainable development." Based on the classical work of Simon Kuznets (see his series of papers in the mid-1960s on economic development and cultural change), the general structural, economic, and social changes that have accompanied economic development are well established. It is clear that there has been a significant directional shift in the relevance of key economic sectors as economic development proceeds. These patterns have been verified using both cross-country and within-country data.

In the early stages of economic development, the bulk of activity takes place in the agricultural sector and in harvesting natural resources. By far the greatest proportion of the labour force (over 90 percent) is engaged in agriculture. As economic development proceeds, one of the most striking patterns is the shift in human activity: the proportion

in agriculture dwindles so that the ratio ultimately is reversed, with 10 percent or less of the population engaged in agriculture, supporting the other 90 percent.

As agriculture falls in relative importance, there is a concurrent rise in the importance of industrial activity. At later stages of economic development, there is a further shift toward the service sectors. Throughout the development process, the importance of international trade and financial flows generally increases, although these aspects are also strongly affected by the international political and economic climate. There have been periods of trade contraction, particularly during recessions and depressions reflecting the efforts of countries to keep commercial activity within their borders.

What are the implications of these economic patterns for ecosystem transformation? One may hypothesize the present environmental predicament has been the result of a series of waves of stress pressures corresponding to patterns of economic development, subsequently modified according to the changing technologies. Naturally, there has also been some (relatively slight) effect from the adoption of so-called "environmentally friendly technologies" and from various efforts to protect the environment by enacting legislation, international accords, protocols, and so forth.

Naturally, the pattern of economic development has strong implications for the patterns of ecosystem degradation. Initial clearing of land for agriculture and subsequent intensification of agriculture had direct effects on loss of critical habitat and extirpation of small and large mammals. In some regions of eastern Canada, more than 90 percent of natural wetlands have been drained for agriculture. Further intensification of agriculture has led to declining soil productivity (when the effects of subsidies are netted out), and in many areas, particularly with wide-row cropping practices, there has been pronounced soil erosion. These changes have led to increased farming pressures on more marginal lands, and declining quality and quantity of the land and soil resource. In the Prairie and parkland belt (the northern fringe of the Prairie ecozone, which is vegetatively dominated by aspen), a number of large and small mammals that were once common are now rare or extirpated. Among the large mammals now extirpated are the plains bison, mountain sheep, grizzly bear, wolf (*Canis lupus nubilis*), swift fox, black-footed ferret, river otter, and wolverine. Among the now rare species are elk, wolf (*Canis lupus irremotus*), black bear, and cougar. Small mammals that are now rare include the red fox, grey fox, mink, badger, raccoon, bobcat, lynx, striped skunk, prairie dog, kangaroo rat, bushy-tailed woodrat, porcupine, beaver, and Franklin's ground squirrel (Bird and Rapport 1986).

Both industrialization and the growth of human settlements have benefited much from proximity to major water bodies – rivers, lakes, estuaries, and coastal marine systems. Not surprisingly, then, next in the general sequence of degradation, is the marginalization of water resources. The most striking examples come from northern and eastern Europe: the Thames, the Rhine, and the Vestula have all been severely degraded by chemical contamination, nutrients, and physical restructuring. A similar fate has befallen many North American rivers (e.g., the St. Lawrence, the Detroit, the Fraser, and the Colorado). Declines in the health of river systems are often precursors to declines in the larger receiving waters. Most of the great lakes of the world as well as the enclosed or semi-enclosed seas have become significantly degraded – this includes the largest inland freshwater bodies such as the Laurentian Great Lakes and Lake Baikal, as well as sizable

semi-enclosed seas (e.g., the Mediterranean and Baltic) and major bays and estuaries (e.g., Chesapeake Bay).

As industrialization intensifies, air becomes the next resource to be marginalized. At the early stages of industrialization, air pollution is localized – confined to the immediate environs of the factory stack. These local impacts may, however, be of devastating proportions – for example, the "moonscape" produced by the smelters at Sudbury. Although there has been a remarkable and largely successful effort to stem these local blights on the landscape, the "greening" of industry is largely a Western phenomenon, having little impact on the worst abuses of industrial production that predominate in much of the developing world (e.g., China and eastern Europe).

As countries reach some intermediate stage of development (e.g., Mexico and Taiwan), diffuse sources of air pollution from the automobile and other vehicles exact a toll on regional air quality. In urban areas, the daily cycle of "dirty air" is well documented – two of the best-known examples being in Los Angeles and Mexico City.

From an ecosystem health perspective, however, it is perhaps not the local effects, as visible and obvious as they are, that pose the greatest risk. More likely it is the global effects of a changing atmosphere, for example, depletion of the protective ozone layer and increased concentrations of so-called "greenhouse" gases. The local "hot spots" of severe air pollution might in retrospect be seen as early-warning indicators of a global marginalization of air resources.

In the later stages of economic development, marginalization of the environment tends to shift from the developed to developing countries. For example, the Japanese protect their remaining forests and trees (the cherry tree is particularly sacred), while harvesting without much restraint the large tracts of Southeast Asian forests; North Americans are seeking agreements with developing countries for dumping industrial wastes that are either too costly to dump or prohibited from being dumped at home; and industries are migrating from areas with restrictive environmental legislation to areas without such restrictions (so-called pollution havens).

Questions of Scale

Given the broad patterns sketched above, the question of appropriate scale for monitoring progress toward sustainable development needs to be addressed. Clearly, the broad patterns suggest the proper scale is at least the large regional landscape, at the level of ecoregions or ecozones, or alternatively major drainage basins. International discussions on sustainable development and the various accords that support that goal are formulated on a national basis. But nations may not be the proper units for assessing progress toward sustainable development, since national borders seldom respect ecological ones. From the ecosystem health perspective, it is clearly possible to functionally define smaller units (e.g., the Great Lakes basin, the boreal forests, and the Prairies) and evaluate these regions with respect to criteria for ecosystem health – reflecting both the underlying organizational aspects of ecosystems and societal values. The size of the appropriate geographical units could vary from the large-scale ecosystem level to landscapes, nations, and the entire biosphere.

When it comes to the landscape level, there are questions concerning the mosaic of ecosystems with differing degrees of pressure from human activity. Can a landscape be judged healthy and sustainable even though it contains elements that are clearly overexploited?

Or, phrased slightly differently, what proportion of a landscape feature (say, riparian zones) might become degraded while the landscape may be judged in good health? Naturally, these considerations suggest that the scale problem needs to be resolved before the indicator question can be properly addressed. Obviously, one needs to know not just what to measure, but over what domain the measurement makes sense.

Indicators of Ecologically Sustainable Development

Tracking progress toward the broad objectives of sustainable development requires first and foremost that the concept of sustainable development be sufficiently refined to be measurable. The concept itself is so all-encompassing that practically any data set could be said to have relevance. The challenge is to select a small number of key indicators that collectively are of sufficient dimension to reflect the general tendency with respect to trends toward sustainable development.

I propose that, in fact, a small set of well-chosen indicators, provided they are adopted internationally, should suffice to reach sound conclusions regarding the "not-improbable futures" for particular regions and nations. These indicators ought to consist, in general terms, of:

(i) measures of the pressures on the environment – in terms of energy and material consumption, adjusted for economic structure, climate, and other factors;
(ii) responses to these pressures in terms of the health of regional ecosystems and their susceptibilities; and
(iii) the potential for society to deal intelligently with surprise – which relates to the knowledge base and its effective use in society.

In this paper, I explore the first two of these three essential aspects of reporting on sustainable development.

(i) Indicators of Stress Pressure

Macrolevel stress on the earth's ecosystems is a very complex phenomenon. It is known that many stress pressures can be transmitted over long distances via atmospheric circulation, or can derive from transactions in the complex global marketplace – this may also shift the "source" of stress some distance from where the actual impacts are felt. Further, there is the potentially sizable mitigating impact of technology. For example, the smelters at Sudbury have significantly reduced both the total discharge of acidic compounds (by incorporating pollution abatement technologies) and the local impacts of the discharge (by means of taller stacks). Other factors influencing the impact of any activity include the degree of recycling in the production process and the natural absorptive capacity of receiving environments.

To evaluate direction of change, that is whether or not stress pressures are increasing or decreasing, a large number of measures may be appropriate – each relating to specific classes of pressure, that is, air pollution, physical restructuring (road network densities), energy generation (dams, size of dams, and nuclear power generation), and so forth. However, by taking into account all such factors, one rapidly encounters "data overload." The alternative is to develop a small group of indicators that are highly correlated with trends in the multitude of specific stress indicators. A detailed study of stress pressures impacting Ontario ecoregions revealed that total population, population density, and energy use were highly correlated with all other more detailed measures of stress pressure and, further, these measures were highly correlated with independently chosen biophysical indicators of the health of regional ecosystems (Rapport 1994). These findings suggest that,

although any number of macroindicators of stress pressures might be chosen, very simple and readily available measures may serve as surrogates (at least for a first approximation) to measure overall stress pressures. In any event, the selected indicators ought to be utilized separately, and one should avoid the temptation to amalgamate them into a supra index, which tends to obfuscate information (Rapport and Regier 1980).

A further complicating factor is the fact that industrialized countries are in a very different situation regarding the origin of stress pressures than are less developed countries. In the former, stress derives from high levels of demand, high per capita use of resources, and powerful technologies; in the latter, stress derives largely from the economics of poverty and basic, minimal technologies.

(ii) Indicators of Regional Ecosystem Health

Here again there is a plethora of key potential indicators of the health of regional ecosystems (e.g., Rapport 1989a, 1989b, 1992a, 1992b; Rapport and Regier 1994). Again, one seeks a subset of indicators, which collectively are sufficient to track the direction of change in the health of regional ecosystems.

As described above, a comprehensive approach to reporting and evaluating trends and conditions in the environment requires systematic tracking of stresses from human activity and extreme natural events, ecosystem responses to stress, and linkages between economy and environment.

The second component, that of ecosystem response to stress, is best evaluated within an ecohealth framework (Costanza et al. 1992). Since a primary objective in reporting on conditions and trends in the environment is to provide information that enables one to predict future states of the environment, it is important to take an explicitly diagnostic approach. That is, our goal should not be merely to document environmental conditions and trends; it should also be to *predict future environments* based on existing conditions and the modes of action of known stresses.

There are four key questions a framework for assessing ecosystem response should address: Is the state of the environment improving or degrading (general screening)? If degradation or ecosystem pathology is found, what are the most probable causes – taking into full account the ecosystem dynamics and lag effects (diagnostics)? What changes may be expected in particular ecosystems in the near future, given present management practices and stresses from human activity (risk assessment)? How can we determine the "healthiness" of an ecosystem, that is, its capabilities rather than disabilities (ecosystem fitness)?

An ecohealth perspective provides the most suitable approach for tackling these questions (Costanza et al. 1992; Rapport, Calow, and Gaudet 1992). This approach, while relatively new to ecology, draws upon a long history of development and practice in the health sciences. The connection to the health sciences gives the approach two additional advantages: (1) it is readily understood by the public, since practically everyone has had first-hand experience in the four key aspects of screening, diagnosis, risk factors, and fitness; and (2) many of its features have been tested for decades by the medical profession. Coupled with the fact that many aspects of ecosystem health are already embedded (some quite fortuitously) in present approaches to monitoring and reporting on the environment, the approach can be shown to be not only

relevant but also very practical.

(a) General Screening Indicators

The purpose of screening indicators is to identify those environments that show signs and symptoms of ecosystem pathology. In other words, general screening indicators are needed to distinguish, on a broad scale, those environments that are in various stages of degradation from those that are healthy – or at least show no symptoms of breakdown.

Screening indicators consist of a number of generic classes that apply across the board to a large variety of ecosystems (Rapport et al. 1985). Ecosystem attributes – such as primary productivity, nutrient concentration, biotic diversity, biotic composition, size and age distributions of dominant species, and contaminant levels in biotic and abiotic components – have been shown to differentiate between stressed and unstressed ecosystems (Rapport et al. 1985). Accordingly, they have a rather solid scientific basis for use as general screening indicators of the health of most ecosystems. Naturally, however, the value of these parameters that differentiate between "healthy" and "unhealthy" states differs according to the particular environment. For example, in the naturally mesotrophic waters of the lower Laurentian Great Lakes, the chlorophyll *a* concentrations are naturally higher than in the oligotrophic waters of the upper Laurentian Great Lakes.

However definitive a single parameter appears to be in particular circumstances, when distinguishing between stressed and unstressed ecosystems it is the entire set of symptoms of ecosystem distress that is required for a more confident assessment. Limiting the assessment to only one or two parameters can often produce very misleading results. For example, Schindler et al. (1985) showed that even after a considerable experimentally induced reduction in pH for small boreal lakes, primary productivity and nutrient recycling remained at near-reference levels. In this case, however, other features of the ecosystem distress syndrome, particularly changes in size distributions of biota and biotic composition, were very responsive to the lowering of pH levels. Thus, for this example, reliance on a few indicators might have suggested that the system was "healthy," while reliance on the set of general screening indicators would have shown definitively that the system was stressed.

A frequently asked question is: is the state of health of the ecosystem independent of the indicators or are they one and the same? If we say, for example, that the lower Great Lakes are unhealthy because the measures of primary productivity, or nutrient concentrations, are in what we have defined as an unhealthy range, then we have defined health by the very parameter we are using to measure it – and we have circular reasoning. On the other hand, we could suggest from comparison with similar systems that, when the indicators collectively show a particular pattern, the ecosystem is severely stressed and well advanced along a path of degradation. In this case our indicators and health are not one and the same thing.

(b) Diagnostic Indicators

Diagnostic indicators, as the term suggests, have an entirely different function from general screening indicators. Their function is to identify causes, not to identify a system that is unhealthy. In other words, once an ecosystem is determined to be unhealthy, the question of why arises naturally. For example, if there is an unusual amount of "dieback" within a forest, resulting in reduced productivity, the forest would be suspected of being unhealthy.

Determining the probable causes of ill-health requires a different, more detailed set of observations than those used to identify ill-health. For example, if dieback in a forest is due to contaminants reaching the canopy and/or soils, a sensitive indicator might be the abundance of feather mosses, which are pollution intolerant. Other diagnostic indicators might include a soil profile for heavy metals, pH levels, and the like. A further diagnostic indicator might lie in the sequence of dieback – where does dieback first appear in the tree and how does it proceed? (For example, is it from the centre outward, or does it first appear at the tree margins and move inward?) In the hands of a skilled practitioner, each diagnostic indicator helps to rule out possible causes of the overall pathology that was detectable from the general screening indicators.

Here arises an important question of the proper levels of biological organization at which to monitor ecosystem health. Our reference is clearly aimed at holistic, systemic indicators of ecosystem structure and function such as productivity, nutrient cycling, and biotic composition. Most ecosystems are well buffered over time to normal perturbations so that long-term changes in these parameters tend to signal fundamental restructuring. However, because these parameters are robust, and because they are responsive to many types of stress, they have high screening potential but low diagnostic potential (Rapport 1990).

To increase the diagnostic potential, it is often necessary to choose indicators at lower than ecosystem levels of organization. For example, the appearance or disappearance of species particularly sensitive to specific stresses may have high diagnostic potential. Similarly, physiological levels relating to changes in enzymes within organisms, the appearance of tumours, and so forth, have been shown in various applications to have high diagnostic potential (Rapport 1984, 1990). The important point is that indicators at different levels of biological organization have specific functions within the overall ecohealth framework.

(c) Risk Factors

Indicators of risk add an entirely different dimension to health assessments. While general screening indicators and diagnostics are designed to deal with existing processes of ecosystem breakdown, risk assessments focus on questions of potential hazards that may not yet be realized or reflected in the ecosystem's data. How can such assessments be accomplished?

Here is one of the best examples of the merits and limitations of the medical approach as applied to ecosystem health. In medicine, it is well established that certain habits – for example, smoking, obesity, and high-fat diets – pose a risk to life. Through well-developed methodologies it has been possible to quantify the risks to individuals for particular health problems (e.g., cardiovascular disease) from various factors. However, to do this requires, in general, a large statistical base – following the exposure and subsequent medical histories of thousands of individuals from a more or less homogeneous population.

Parallel opportunities rarely exist with respect to ecosystems and their exposures. However, in well-studied pathologies, particularly those involving exposure to acid precipitation and nutrient stress, it has been possible to quantify the relationships between exposure and ecosystem effects. For example, acidification has well-known impacts on unbuffered lakes – resulting in significant losses in biodiversity. Minns et al. (1990) have used risk assessment techniques to predict losses in biodiversity in fish taxa in eastern

Canadian lakes. Through these techniques it is possible to evaluate the potential impacts of dominant stresses before symptoms of ecosystem pathology appear.

(d) Fitness

I use fitness here in the context of fitness medicine – where the emphasis is on preventive health. This has no direct relationship to the evolutionary biologist's concept of fitness, and the use of the same term in medicine and evolutionary biology may cause some confusion. However, I would defend the use in this context as appropriate, for there is the need to test the "healthiness" of the system before it has lost its resilience.

Indicators of ecosystem fitness address the question of system capabilities, rather than system disabilities. Here again, a direct parallel is found with the health sciences. In fitness medicine, it is not disabilities, but capabilities that are measured. Capabilities and disabilities may well lie on opposite ends of the same scale. For example, in lung function, the loss of capabilities may become a disability – normally some loss can take place, since for normal physical exercise, there is generally a surplus lung capacity. However, loss of capacity may foreshadow the development of impairments that become disabilities.

The application of this concept to ecosystem monitoring is just beginning. The concept was only recently advanced (Rapport 1992a, 1992b), and field testing will begin in 1994 on the Jornada Long Term Ecological Research Site (New Mexico). In these tests, arid grassland recovery from natural disturbance (mainly drought) will be monitored (retrospectively) through the use of remote sensing data and historical records. There will also be experimental tests using rain-out shelters. The hypothesis is that restoring primary productivity and community structure is slower and less complete in those systems that have been chronically stressed, for example, by overgrazing, or by applications of herbicides. The measure of loss of capabilities would be the speed of recovery compared with that of the unstressed ecosystem.

Conclusion

Reporting on sustainable development ought to be based on an ecological perspective, within which questions of temporal and spatial scale are resolved and the concept of ecosystem health is given a primary focus. The large-scale erosion of ecosystem health can be abated if the public is made more aware of the implications of present trends in the loss of ecosystem services and management options. Borrowing from methodologies developed in the health sciences, a systematic monitoring capability at the regional scale is possible, and four specific groups of indicators are recommended to serve various functions ranging from preventive health care to curative measures.

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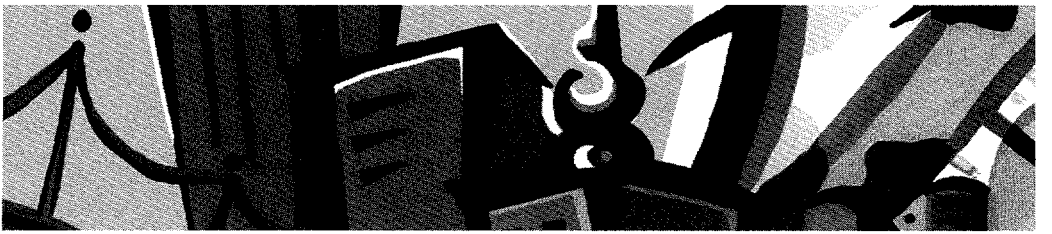

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Presentation by David Rapport

Ecosystem health is a concept that is far broader than sustainable development. It is transdisciplinary; it goes beyond individual disciplines such as biology, economics, and the health sciences; and it does not separate into components that are addressed in isolation such as the socioeconomic disciplines, ecology, and human health. Under an ecosystem health concept, all disciplines are part of a single system.

It is a concept that contrasts with traditional approaches to dealing with individual systems. Agroecosystems, for instance, are usually viewed from the perspective of specific disciplines or sectors. If yields are up, the economic sector is pleased and supportive. At the same time, in another corner of society, the environmental movement is distressed over evidence of worsening soil degradation. And in yet another corner, the extremely high rate of injuries to farm workers is being tracked. Rarely, however, is there an all-inclusive, transdisciplinary perspective that looks at the health of the entire system.

Identification of suites of indicators and syndromes are in the offing, even if the ultimate indicator is not. Consequently, we should be working on identifying relationships.

First of all, however, what is health? How should we define it? Is it based on a series of tests? The answer to that is no. Ultimately, it is based on a holistic assessment and that assessment involves values. What constitutes health will change according to goals and aspirations. It is a social assessment, but one that takes in all social values. The difficulty is that once we talk about values, people become uneasy, especially the scientists.

If we look at any system over time, we see tremendous changes that are independent of human intervention. For instance, North American forests greatly altered their species composition and character over past millennia. Now, however, human intervention is the major cause of change. And when human values change, so does the type or extent of intervention. For example, wetlands were largely eliminated

in southern Ontario as farming intensified to make use of marginal lands. In the latter part of this century, however, wetlands were seen to have value as wildlife refuges and, as a result, conservation strategies have been implemented to encourage their retention.

So, a shift in values can result in huge changes within systems. Does that mean anything goes as long as we apply different values? Are there no boundaries to values? The answer is that of course there are boundaries. Values must conform to the envelopes of systems.

Envelopes are composed of the different pathways, or manifestations, of the development of systems. Ecological systems are by no means deterministic. They are influenced by many random events both within and external to the system. As a consequence, many ecosystems have multiple semi-stable states, and they may exhibit a number of different developmental pathways. However, the potential for alternatives is not unbounded. Overall, the integrity of the envelope – which contains all possible pathways and system manifestations of a healthy ecosystem – must be maintained. Otherwise the system becomes transformed into another system altogether. When this occurs as a result of stress on the system from human activity, the result is often a degraded state of the ecosystem, as represented, for example, by the acidified lakes of eastern Canada. Their current condition, with the loss of key fish species and higher pH levels, falls outside the envelope of normal development patterns and pathways.

Values are related to different spatial domains at the local, regional, and global levels. Health values, for instance, tend to operate at the community level. At the regional level, we have values that relate to intergenerational issues, such as sustainability or the preservation of ways of life. These values can change, as in the case of wetlands, but within the envelope, where various systems operate, ecosystem integrity has to be maintained. A change in values is not acceptable if it destroys the conditions for mutual dependence that have developed over time. In other words, a change in values that will modify a system is acceptable only if the integrity of the envelope is assured.

Measuring activities is part of the means of measuring the state of any system. For example, in medicine we check specific things – blood pressure, pulse, and so on – and add them up to assess health. However, the evaluation of shape and condition always refers to the envelope and to what exists outside the envelope. And the range of criteria that are examined go well beyond any one discipline.

It may be far more costly to intervene when things have reached a crisis. So how can we anticipate? That is where context comes in. Indicators are not much help unless there is a context because they cannot be assessed without one. That raises the possibility of turning to indicators of risk. Even if there is no apparent decline in a system, its ability to handle stress may be reduced. Indicators of risk might help determine the point at which cumulative impact begins to break down a system.

One way of trying to anticipate is through backcasting in the hope of forecasting, that is, looking at the past to assess whether indicators, if they had been used, would have pointed to what has happened in the present. If they were valid for the past, they may be useful in pointing to the future.

The real challenge is to integrate across social sciences and to integrate human activity with ecosystem activity.

Response

Synopsis of Response

Participants in the colloquium, for the most part, thought that a health metaphor could be very useful in communicating concerns about sustainable development. But beyond that it had limitations. There was no attempt to develop a consensus on what methodology should be adopted to assess sustainability. Nevertheless, a few themes emerged around which there appeared to be general agreement. They were:

- the most pressing need is to anticipate change;
- any system of reporting and assessing will have to accommodate unpredictability and high levels of uncertainty;
- to be meaningful, indicators must be established within a clear context;
- assessing ecological states will require a capacity to address a multiplicity of decision-maker needs and a multiplicity of ecological particulars; and
- it is unrealistic to expect that it will be possible to develop universal indicators, or even a small set of key indicators, for entire ecosystems; instead, specific indicators for specific parts of an ecosystem should be sought.

Critique

(The formal task of critiquing Prof. Rapport's paper was undertaken by Anne Kerr. Other participants contributed.)

Taking the health analogy too far does not help in dealing with specific issues. Already we have many of the generic elements necessary to establish a reporting system. So, do we really need new terms? And why should we continue trying to expand indicators beyond their established use?

Prof. Rapport has identified many attributes that can be used to address problems of scale and some screening mechanisms already are in place. It is crucial to move forward and to ask practical questions, such as: which ecosystem services are threatened? What options are available for addressing them? And what management systems should be put in place? What we need more than anything else at this juncture is a very practical approach.

Concern over the concept of ecosystem health focusses on its normativeness. It is criticized for not being scientific enough. However, the problem is not that it is not scientific enough; it is that it is too scientific. The problem is with the degree to which it absorbs the reductionism of health. The difficulty we face in reporting on sustainable development is that we are talking about specific measurements that are purely objective. We need to include normative standards.

Despite the fact that health is approached as a reductionist exercise, it is inherently normative. We are talking about what we like. When we introduce the concept of ecosystem health into sustainable development, the measurement shifts from the purely objective to include what we like. So the word health is attractive simply because of its normativeness. It would be much better to maintain a multi-attribute approach and to apply a multi-attribute analysis.

Some writers, for instance, draw a distinction between health and well-being. Without a multi-attribute approach, how do we contend with that? Then again, C.S. Holling of the University of Florida in

Gainesville says that what we must preserve is the capacity of a system to flip into inherently unpredictable changes. How do we make decisions about that?

A caution must be voiced against becoming too reductionist because it can impede the ability to communicate. For instance, there is some merit in focussing on owls, or cougars, or what have you. Trying to communicate with people about the rate at which nitrogen is being fixed to the soil is not nearly as sexy.

The overriding question should always be: what kind of information do decision makers need? Insurance companies concerned with damage claims resulting from hurricanes looked for a factor that would allow them to link cause and effect. They found one such indicator in ocean temperatures: when the surface temperature reached 28 degrees Celsius, the likelihood of a hurricane forming is substantially increased. They also discovered that there is an expansion of areas where surface temperatures are that high. Consequently, companies are becoming very reluctant to issue standard insurance policies in cities such as Tokyo and New York.

Communication, however, also involves being aware of sensitivities. For instance, governments in the United States do not want to use the eagle as an indicator species because they do not want negative feedback from people concerned about the U.S. national symbol.

We measure outcomes in social systems; that is what we care about, not descriptions. It is the disease, the pathologies, that we care about most as an indicator, more so than overall health.

Commentary: Making Observations, Posing Questions

The problem with indicators is that what is good for one part of the system may not be good for another part. We have been trying to track down a Holy Grail that does not exist. The question is: what do we mean by an indicator? Is it measuring a change? Surely the answer is no.

But perhaps that is not the issue at all. The real issue may be the validation of indicators. Anyone can propose an indicator, but to be valid it has to have some capacity to reflect the state of the larger system. For example, unemployment figures, inventories, or new housing starts are generally thought to be reliable indicators of the business cycle.

There is no such thing as a universal set of indicators. All indicators must be established within a context. There are indicators that are accessible and usable such as, for instance, the UV index numbers that are broadcast with the news most days. They remind people about ozone depletion and the danger of exposure to ultraviolet rays. But do they *indicate* anything? And do they report on progress?

Within Environment Canada, there is pressure to develop a compact set of indicators, but it is unlikely that it will be possible to do so. Individuals and householders need criteria. But we cannot give them one number, and, if we give them 50, it is confusing. Perhaps what people need is a smaller set of information on a smaller set of the ecosystem, for example, the Fraser River basin.

What we should be moving to is something that speaks to a much larger audience. The big mistake would be to make predictions. We cannot make them and it would be crazy even to use a predictive framework. Even the concept of prediction is problematic.

Granted, some predictions have been wrong, as they were on energy demand. On the other hand, we should not throw the baby of prediction out with the bathwater of error. Prediction is simply linking cause and effect. If we are not getting the right prediction, it is because there is something wrong in the dynamic of cause and effect.

We have to be more careful about how we use the word "prediction." We cannot make predictions in the same way that classical laboratory biologists or ecologists can where they establish predictability based on repeatable experiments under closely controlled conditions. However, we can make "assessments" of "not improbable futures" based on allowances for uncertainty. This is the basis of risk analysis. We can use already-observed relationships between human activity and degradation of ecosystems to predict ecosystems at risk before signs of degradation are obvious.

One of the major difficulties we face is to determine exactly what it is that we want to conserve. Ecosystems are constantly changing. For instance, in Cape Breton, farmers are leaving the land and, consequently, the landscape is changing. Is that good or bad? What yardstick do we use for the desirability of change?

The key question to be addressed is: what does sustainability mean within the range of change that we are talking about? Indicators do not look at static points in time; they look at trends over time.

In areas such as biodiversity, habitat, and landscape, it is much more difficult to come up with indicators. Landscape change happens at the local level, but its impact is regional. When the landscape is transformed, there will be a loss of top predators, and that may be the necessary price of agriculture. The question to be put to Prof. Rapport is: how do you bring into the sustainability equation these large-scale questions of biodiversity?

The question to ask, Prof. Rapport responded, is whether there is a mosaic that makes sense. And if there is, how do you get at it? There is a need to do more analytical work, since we do not know enough about deficits and benefits. We need to identify crosscutting indicators that can be seen as integrative; we need to focus on specifics, but we also need indicators that reach farther afield.

For instance, if farming leads to the elimination of a valued fishery or of waterfowl because of the toxic effect of pesticides, then the health of the agro-landscape is adversely affected. Even if crop yields are maintained and farm operations remain profitable, the health of the agro-landscape is compromised. This expanded concept of ecosystem health is what we mean when we talk of sustainability of the larger integrated landscape – and by that we mean not merely the sustainability of crop yields, but the sustainability of the larger integrated landscape, including wildlife and fisheries.

In a further observation, a participant pointed out that regions do not have control over their landscapes. Decisions affecting them are made in New York, Tokyo, and London. That is how the global economic process works. A decision about where a rubber plantation will go is not made on site.

On a practical note, we have ecosystems that are dying, where there are no fish, or timber, or basic resources. Why not see what can be done within those systems to develop sustainability?

The issue is one of goals. In the case of the Great Lakes, the issue comes back to the Great Lakes Water Quality Agreement, which is based on an intent to look at the basin as an ecosystem and to scale it up. The whole exercise of setting goals and working backwards with indicators has been very helpful.

There is also the question: how clean is clean? The public response may be, "When people can swim in it." A professor of chemistry may say, "Pay me for a survey to do mapping and I can tell you." An engineering firm will say, "When regulatory standards are met." And an ecologist will answer, "This is not the question to ask; it is an issue of ecosystem integrity." The point is that they *all* are correct. You have to respect all of them. Each of them has different needs.

Discussion: Offering Suggestions

For years we have been dealing with lists, and diagrams, and charts, and so forth. Now we are trying to attach all this to the concept of sustainable development. It would be very easy for us to go around in circles. In fact, often we are doing just that. Many people have been saying much of what is being said at this colloquium since the 1970 conference in Stockholm. We need to focus on dynamics. In other words, process and change. The world is going through a rapid transition. Things are happening very fast. For instance, in Asia there has been tremendous growth in the middle class and consumption is increasing dramatically. To deal with the dynamics of what is happening, we need to know what we have to conserve in order to know what to consume. We have to go back to the traditional view of economics that deals with frugality or we will not get anywhere.

There may be virtue in more frugality when it comes to overconsumption, but there is no value in returning to the traditional view of economics. The problem with the traditional approach is that it leaves out entirely the important reactions between the human economy and the supply of ecosystem services. That is why economic development has, by and large, been at the cost of ecological capital. The price of that kind of development has been measured in much reduced ecological services and truncated management options.

What is needed are indicators that will measure the impact of specific actions on specific parts of the ecosystem. We do not need a static indicator of ecosystem health. All that tells us is where we have been; it is not anticipatory. Within the notion of sustainable development, people can see many things. That is its strength. Its weakness is that we cannot go forward if we deal only with the state of entire ecosystems.

Prof. Rapport responded by saying that what is needed are indicators of the resilience of ecosystems, so that when stress begins to build up, it can be relieved before irreparable damage is done.

Most government decision makers cannot handle pluralism, another participant pointed out, and we have to deal with this. As has been said, time and again, all indicators are contextual and without the context they do not mean very much.

The public needs guidance and assistance. If they do not receive it, they will develop their own indicators, just as insurance companies did in order to deal with the impact of hurricanes on their payouts.

The reality is that when we look at indicators, some are up, some are down, some are up a lot, some are down a lot, some are up a little, some are down a little – and we are faced with making some kind of decision. To talk of sustainability in an ecosystem is to talk about making judgments. What we need to do, just as is done in legal systems, is to make judgments and to give reasons. Otherwise there is no way for people to grasp what it means when they are faced with information that says that, in the Great Lakes, the level of toxic contaminants is dropping dramatically but the toxic contaminants in fish and wildlife are not dropping at all. Moreover, we need

to give reasons for our judgments for two further reasons: first, so that we set benchmarks against which to measure progress in later years; and, second, so that when we make a mistake, we will know in which direction to move.

Another participant felt that it is ultimately necessary to reach a judgment; however, as systems keep improving according to the indicators, people feel increasingly insecure. Why is that? Probably because the indicators do little or nothing to lower the level of uncertainty. There is a concept of a new science developing that deals with complexity and the fact that changes may not be predictable. Where change is unpredictable and we are dealing with uncertainty, we cannot make judgments unless we have some idea of the dynamics of the process. The key to approaching judgment in these kinds of situations lies in ethics – in value systems.

To return to the observation of Prof. Holling, what we need to do is fashion a judgment-making process that incorporates the capability of dealing with inherently unpredictable change.

Decisions are governed by the mindsets of people. In trying to assess their mindsets, it is impressive how well their conceptual frameworks operate to suit their needs. So, what we should be doing is trying to link the fundamental factors that lie underneath the various conceptual frameworks. Decision making governs what people do. We do not tell trees what to do; all we can control is the person with the chain saw. The only thing we can control is the human subsystem of the ecosystem.

Ecosystem, ***Interaction***, People, Synthesis

The focus of Mr. Schrecker's paper was the second of the four indicator domains identified by the National Round Table as providing the basis for a system of reporting progress on sustainable development in Canada. This domain is concerned with assessing the interface between people and the ecosystem.

Commonplaces and Heresies about the Human-Ecosystem Interface

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Introduction

For purposes of organizing systems of sustainable development reporting, Tony Hodge identified four domains of data and information.[1] This paper attempts to address the domain to which Hodge refers as the interaction between people and the ecosystem; it is subsequently referred to for convenience as HEI, an acronym for human-ecosystem interface. According to Hodge, the basic principle for reporting information about this domain is that: "Ideally, human activities would be classified and assessed in terms of their 'value' (contribution to provision of basic needs and an enhanced quality of life) and by the physical, chemical, and biological stresses they impose on the ecosystem."[2]

The approach adopted here is somewhat different from that of Hodge, but the differences involve emphases and style rather than basic conceptual disagreements. I am less prepared than Hodge to treat many stresses imposed on ecosystems by human activity as prima facie undesirable. Economic activity is first and foremost about the provision of livelihood, whether or not it takes place within the so-called formal or money economy. Our frequent indifference to this fact is a result of chance and situation. As political scientist Ronald Inglehart has pointed out, part of the explanation for the distinctive value orientation he refers to as post-materialism is the fact that postwar industrial societies "are a remarkable exception to the prevailing historical pattern: the bulk of their population does not live under conditions of hunger and economic insecurity."[3] In addition, virtually all economic activity involves some degree of stress on ecosystems, even though that stress may appear insignificant. We can tread more lightly on the earth, but we cannot make ourselves weightless. Consequently, there are almost always tradeoffs to be considered

between stresses on ecosystems and the more ample or effective provision of livelihoods.

The definition of enhanced quality of life, and to some extent even that of basic needs, is inescapably both subjective and context-specific. For these reasons among others, I am therefore more inclined toward definitions and conceptualizations of sustainability that are fundamentally economic in nature. Whatever their shortcomings, which are many, markets do provide a remarkably reliable way of discerning the preferences of a particular subset (the subset with purchasing power) of any given human population. In addition economics, through the synthetic discipline of political economy, provides a set of assumptions about the motivations for human activity both within and outside market settings that are admittedly flawed and incomplete, but nevertheless appear to have more analytical and predictive power than any alternative set of such assumptions. At the macrolevel, this point is illustrated in recent research on the political economy of transitions from authoritarian rule.[4] At the microlevel, the point will be self-explanatory to anyone who has observed the behaviour of academic colleagues when scarce resources such as salary increases, new appointments, research assistance, and sabbatical leaves are to be allocated.

Finally, I think it important to emphasize that a particular development pattern might meet a variety of plausible criteria for sustainability and nevertheless constitute bad (or at least thoroughly contestable) public policy. Sustainable development should not become a surrogate for any particular policy analyst's vision of Utopia. Core criteria for sustainability must be specified with precision, and must be transparent enough to facilitate disagreement about their adequacy. Reporting systems that provide a basis for assessing compliance with those criteria must likewise be designed to facilitate informed disagreement, perhaps even to encourage it.

Reporting on the state of the HEI should provide the information necessary for accomplishing four tasks: (a) modifying Canada's present system of national accounts, based on a constant-wealth or constant-capital criterion; (b) determining whether human activity fails to meet sustainable minimum standards (SMSs) for several kinds of ecological impacts; (c) assessing the distribution of costs and benefits from human activity that has adverse ecological consequences; and (d) developing "provocative indicators" that provide the basis for imaginative predictions of the future state of our society but also reflect, as accurately as possible, people's own assessments of their quality of life. My discussion of the information needs associated with these tasks is necessarily non-technical in nature. It is concerned less with the details of the sustainable development reporting system than with what users might need, or want, to get from those systems. I have also not tried to assess whether existing information-gathering and reporting systems, in Canada or elsewhere, are adequate for these purposes.

Constant Wealth

The now-familiar Brundtland Commission definition of sustainable development is that which "meets the needs of the present without compromising the ability of future generations to meet their own needs."[5] The etymology of the word "economics" suggests the following analogy: like a household's accounts, the accounts of a national economy should provide an indication of the extent to which a nation will be capable in the future of meeting the basic material needs and aspirations of its

constituents.[6] This should be the conceptual starting point for any effort to define sustainable development in a way that is relevant for public policy.

The limitations of the information about such prospects that is provided by existing systems of national accounts were powerfully demonstrated by the efforts of Robert Repetto and his colleagues to adjust the national accounts of resource-dependent economies to take into account depletion and degradation. Such adjustments in the case of the fast-growing Indonesian economy, taking into account not only the contribution of its resource industries to the nation's economic product but also the economic losses associated with "depreciation" of the forest resource, soil degradation, and depletion of oil and gas reserves, resulted in a rate of economic growth considerably less impressive than the unadjusted figure. Even more important than this change in overall magnitudes was the comparison between gross domestic investment and resource depletion. "In most years during the period [studied] ... the depletion adjustment offsets a good part of gross capital formation. In some years, net investment was negative. A fuller accounting of natural resource depletion might conclude that in many years depletion exceeded gross investment, implying that natural resources were being depleted to finance current consumption expenditures."[7]

More recently, researchers working with the United Nations Statistical Division (UNSTAT) have developed similar but conceptually and operationally more sophisticated modifications to the national accounts of Mexico and Papua New Guinea.[8] In addition, David Pearce and Giles Atkinson undertook a comparative exercise in which they tried to assess the sustainability of 21 national economies, based on modifications of data from national accounts. They concluded that the economies of 11 countries were sustainable; those of 8 others (including Indonesia) were not sustainable; and those of the final 2 were marginal. Canada was not included in the comparison.[9] The data used were highly incomplete, and their relevance to sustainability not always fully explained or justified. Conceptually, the exercise was nevertheless highly significant because it provides an indication of how the long-term survival and growth potential of national economies might be compared, taking into account the constraints imposed by ecology-economy linkages.

The Pearce-Atkinson exercise exemplifies the application of a weak sustainability rule, which simply states that "an economy is sustainable if it saves more than the depreciation on its man-made [sic] and natural capital."[10] This may also be thought of as a criterion of non-declining wealth. The Brundtland criterion of intergenerational equity is met, but in a way that fails to challenge the generic neoclassical assumption that human-made capital can be substituted for natural capital. The significance of such an approach in the case of resource-dependent economies should be clear even to those decision makers whose prior concern with ecological values and indicators is minimal. There are many potential objections to such a rule, and to such an assumption. Pearce and his colleagues are themselves sceptical, and have argued for a more restrictive criterion of constant natural capital (CNC). The value of ecosystems, they suggest, cannot be reduced to their role as suppliers of raw materials that can be extracted or harvested, sold, and turned into marketable products. Ecosystems also provide a variety of services to human beings for which there are at present no credible substitutes: "No one has yet found a way of (feasibly) recreating the ozone layer, for example.

The climate-regulating functions of ocean phytoplankton, the watershed protection functions of tropical forests, and the pollution-cleaning and nutrient-trap functions of wetlands are all services provided by natural assets and for which there are no ready substitutes."[11]

Peter Victor has pointed out that there are several ways of interpreting and operationalizing a strong criterion of sustainability, each of which is problematic. Trying to assess the sustainability of an economy or a set of human activities based on inventories of the stock of natural capital raises the problem of the incomparability of physical units: "If the standing stock of timber increases at the same time as the deposits of natural gas decrease, how can it be determined whether the stock of natural capital has risen, fallen, or stayed the same?"[12] What additions to natural capital should be taken as sufficient to compensate for, say, specified reductions in biodiversity? for desertification that directly or indirectly contributes to famine? Assigning dollar values for purposes of making such comparisons tries to get around this problem, but in the process introduces many others. Some of these problems are by now familiar: markets do not exist for many of the services provided by ecosystems; negative externalities generated by production of marketed goods and services are indirectly reflected (or not reflected at all) in market prices; common property resources are effectively priced at zero; and valuation methodologies are highly sensitive to initial (explicit or implicit) distributions of wealth and entitlements.[13] Other problems are less familiar. For instance, as Victor points out: "If price or net price rises as resource quantity is declining, the value of resource stocks as an indicator of sustainability will give precisely the wrong policy signal to government," since the increase in the value of remaining stocks may more than offset their declining quantity or quality.[14] How credible is the process of assigning monetary option values to the preservation of species when the existence of those species may not yet be known, or when their role in maintaining ecosystem functions is incompletely and imperfectly understood?

The arguments for adopting a strong rather than a weak criterion of sustainability for reporting purposes might be compelling if a modified system of national accounts were the only component of reporting on the HEI. If instead the system of national accounts is used as only one component of reporting, they become far less compelling. Indeed, a weak sustainability criterion emerges as preferable. If a weak sustainability criterion is properly applied to the modification of national accounts, the question being asked is restricted to whether and how particular human activities have a demonstrable impact on the future income-generating potential of the assets that comprise the capital stock of a national economy. Although applying a weak sustainability criterion may not provide a comprehensive answer to this question, it forces some important analytical distinctions. For example, many categories of pollution that we may regard as highly undesirable, and that may stimulate significant "defensive expenditures," nevertheless do not have a significant impact on the economy's income-generating potential. In addition, concentrating on ecological impacts to which a dollar value can clearly be attached, and which are comprehensible in the conventional language of national accounting, powerfully illustrates the link between sustainability, economic growth, and savings. Finally, this approach may strengthen the case, and the consensus, against the most egregious instances of mismanagement of

natural endowments: the ones that make no sense even if all one cares about is aggregate monetary gains or losses.

It must be emphasized once again that I am not making an argument for weak definitions of sustainability per se, but rather for their use in one component of sustainable development reporting. An economy that does not meet even a weak criterion for sustainability is probably in for serious long-term difficulties. An economy that does meet such a criterion may nevertheless confront such difficulties, but their significance is best assessed and demonstrated in ways other than by modifying systems of national accounts.

Safe (or Sustainable?) Minimum Standards

An extensive body of research links a variety of adverse health impacts in fish, birds, and mammals to several anthropogenic contaminants present in the lower Great Lakes.[15] Advisory bodies to the International Joint Commission (IJC) have adopted a "weight of evidence" approach to determining the significance of these findings for human health, whereby this body of evidence is used in conjunction with available knowledge about mechanisms of toxicity and accumulation to determine for policy purposes whether pollution-related hazards to human health should be presumed to exist.[16] The Commission has accepted this approach as the basis for recommending more aggressive efforts to reduce the use, production, and discharges of a number of contaminants, specifically organochlorine compounds.[17]

Superficially, this is an example of what has come to be called the precautionary principle. The IJC could instead have held that conclusive scientific evidence of contaminant-linked human health effects was needed as the basis for recommending changes in policy. This latter approach has been characterized by one environmental economist as one requiring "positive evidence of 'dead bodies' before acting,"[18] and by another as a "cigarette company standard of proof," referring to the tobacco industry's long-standing claim that "the etiology of cigarette smoking and lung cancer has not been 'scientifically demonstrated'."[19] However, despite its appeal in specific and familiar contexts the precautionary principle is ultimately vacuous unless it is interpreted to mean taking precautions against a particular form of environmental damage or resource degradation *at any cost.*

That advice is presumably not what the IJC intended to give, and indeed in many contexts would be thoroughly irresponsible: "If a developing country has the choice between (a) investing in scrubbers on power stations to prevent acid rain and (b) building hospitals, it will build hospitals first. And it will make more sense to persuade local industry to dump its toxic waste with reasonable safety than to treat the stuff to American levels."[20] The costs of such high levels of control would be prohibitive, and the effect on economies with limited resources of trying to pay them would be destructive of those economies' ability to meet basic needs. In addition, the ability of societies to make the investments needed to reduce a variety of environmental stresses, many of which have direct consequences for human health, appears to be directly correlated with increasing per capita income.[21]

Prohibitive costs, limited resources, and competing priorities are problems confronting not only developing countries. Some references to the precautionary principle, but by no means all, incorporate explicit consideration of potentially destructive implementation or compliance costs.[22] For this reason, a useful

alternative approach may be that of trying to define safe, or sustainable, minimum standards (SMSs). "The SMS approach states quite explicitly that we should avoid irreversible environmental damage unless the social cost of doing so is unacceptably large. The rule sounds imprecise, but the SMS approach is deliberately 'fuzzy' because it does not rely on a single criterion for making discrete choices."[23] The irreversibility of environmental damage need not be the only characteristic of concern. The response of some types of ecological systems to increased levels of stress is complex, non-linear, and therefore difficult to predict on the basis of presently available knowledge.[24] Against this background, SMSs incorporating a margin of safety may reflect a highly rational aversion to uncertainty where the probability of particular outcomes, such as the collapse of a particular fishery or the near-worst-case scenarios associated with global warming, cannot reliably be determined or calculated.[25] The inclusion of global warming in this category admittedly depends on how uncertain, unpredictable, and potentially catastrophic one believes its progress and impacts to be.[26]

As suggested by my reference to safety margins, SMSs are inescapably subjective and context-specific. Quite apart from the justice or injustice of internal distributions of wealth and power, SMSs that make sense in a rich country may not make sense in a poor one, or even in the poor regions of a rich country, given resource constraints over which the people whose futures are at stake have no control. In many cases, the content of SMSs will be hotly contested, as is shown by the relatively trivial example of the conflict over eliminating chlorine compounds in the effluent streams of Canadian pulp mills. I view this as an advantage, since the process of arriving at such a standard means that tradeoffs and conflicting priorities are more likely to be articulated clearly. However, the nature of this process of articulation creates special demands on reporting systems. They will need to provide reliable information about the connection between specific human activities and the ecological outcomes that are of particular concern. They must also provide information about the magnitude and distribution of the costs of the feared outcome, about the rewards and beneficiaries of the activities that lead to it, and about the costs of avoidance. The reference to distribution, which is expanded upon in the next section of the paper, reflects the fact that avoidance costs may be considered tolerable in the aggregate, but intolerable if they fall most heavily on a particular region, group, or class. "Costs" in this context is a term that can and normally should be defined quite broadly.

The SMS approach has perhaps been explored most extensively in the area of conserving biodiversity, where Richard Bishop has stated that: "Adopting the SMS strategy as an objective of policy would mean avoiding extinction in day-to-day resource-management decisions. Exceptions would occur only when it is explicitly decided that costs of avoiding extinction are intolerably large or that other social objectives must take precedence."[27] The SMS principle, whose context-specific nature is clearly acknowledged in Bishop's formulation, is particularly appropriate here given the unpredictable nature and magnitude of the costs of failing to conserve biodiversity, but the principle also merits application in a variety of other areas characterized by similar conditions of uncertainty or incomplete knowledge. For example, Timothy O'Riordan and Steve Rayner have identified four types of global change for which risk management strategies are required: biospheric catastrophe; climate perturbation; (further) undermining of

basic needs provision; and the accumulation of micropollutants with potentially chaotic long-term consequences.[28] Arguably, SMSs of one sort or another are an appropriate response in each of these cases. Perhaps even more importantly, given the conceptual framework of this paper, SMSs are relevant even (perhaps especially) to economies that manage to meet the weak criterion of sustainability by way of a modified system of national accounts.

For purposes of sustainable development reporting, agreement is not necessary on the precise content of an SMS. In particular, agreement is unnecessary and indeed improbable on the definition of intolerable costs. However, it is important clearly to identify the types of ecological damage against which it is thought appropriate to take the SMS approach. It is also important to provide as much detail as possible about the human activities that generate or are associated with that damage and about the nature of the causal connections, both direct and indirect. Thus identifying emissions from internal combustion engines as a major source of carbon dioxide gives only part of the picture. On the other hand, the information that urban population density per hectare in the industrialized world is strongly correlated with gasoline consumption per capita and its environmental impacts, including carbon dioxide emissions,[29] provides far more insight into the dynamics involved. Finally, since the SMS approach incorporates explicit reference to unacceptable costs, reporting should provide the information necessary to determine the magnitude and incidence of the costs of meeting the SMS. The question of incidence is explored in the next section of the paper.

Distributional Considerations

"It is perfectly possible for a single nation to secure a sustainable development path . . . *but at the cost of non-sustainability in another country.*"[30] At the macrolevel, the example of Japanese and European Economic Community imports of tropical hardwoods provides a useful example. On a weak view of sustainability, Pearce and his colleagues note that this need not matter, since "the hardwood exporting countries may simply be converting their export revenues into investments which will sustain their future. . . Unfortunately we have little evidence that this is happening."[31]

One of the merits of the approach to national accounts I have suggested is that it could provide both exporting and importing countries or regions in question with the information needed to determine whether this is the case, assuming for the sake of argument that they care. On a strong view of sustainability, one sceptical about the substitutability of natural for human-made capital, concern would be focussed instead on actual forest management practices, on the potential for reforestation or ecosystem rehabilitation, and on the possibility of substitution or compensation for the services provided by the relevant forest ecosystem(s) . . . in other words, on uncertainty and irreversibility. In either instance, it is clearly worth knowing whether and how particular national or regional economies are importing sustainability by exporting the various ecological costs of human activity.

William Rees's concept of ecological footprints could make a major contribution to addressing this question, if it were used as an organizing principle for information gathering and reporting systems. Urban

regions and developed countries alike, according to Rees, may be "importing sustainability" not only by way of importing physical resources, and thereby exporting the environmental degradation associated with their extraction or cultivation (e.g., in the case of input-intensive plantation agriculture) but also by appropriating the use of ecosystem functions not directly related to resource trade.[32] For example, it could be argued that fossil fuel consumers in rich countries rely on the carbon dioxide absorbing function provided by tropical moist forests, which they obtain at a price of zero. The terms of ecological trade must also be considered. Despite the Brundtland Commission's efforts to draw attention to this problem, we often forget how the power dynamics of international trade and investment leave developing countries as price-takers on commodity markets, often with devastating effects on their domestic economies and ecologies.

An intriguing recent proposal originating in the United States reflects the same underlying concerns as the ecological footprint concept. It would provide information about various costs and benefits of human activity by requiring major consumer product firms to prepare social-environmental impact statements detailing "the impacts of extracting, transporting, and transforming major raw materials, and of the production, testing, use and disposal of consumer products." They would provide information on environmental damage as well as on such issues as wages, working conditions, and human rights violations in the product's country or region of origin. The impact statement requirement would encompass the activities of suppliers of major inputs as well as those of the product's final manufacturer or marketer. "Who knows how many companies will uncover, in the course of preparing their SEIS, direct links to Chinese prison camps, Khmer Rouge lumber operations, exploitation of child labour, clear-cutting of the rain forest, or other insupportable activities?"[33]

This form of reporting could serve the needs of various decision makers. However, it must also be noted that the existence of low wages, deplorable working conditions, and abysmal environmental quality does not necessarily mean that the people in question have any options that are more attractive; indeed, the discussion of immigration later in this paper suggests that this is often not the case. One need not accept the neoclassical economic response that a rising global economic tide will in time lift all boats; indeed there are abundant reasons to reject it on both ecological and political grounds. At the same time, we must recall the dilemma of industrialization stated eloquently by Barrington Moore at the conclusion of his study of Indian economic development, one which has far broader relevance: "the poor bear the heaviest costs of modernization under both socialist and capitalist auspices. The only justification for imposing the costs is that they would become steadily worse off without it." The dilemma is "indeed a cruel one," but "to deny that it exists is, on the other hand, the acme of both intellectual and political irresponsibility."[34]

Another approach to the spatial distribution of ecosystem impacts that is by now familiar involves comparing the consumption of energy and a variety of other resources in rich and poor countries. The Brundtland report points out that countries with 26 percent of the world's population account for 80 percent of the world's commercial energy consumption, 79 percent of its paper consumption, and 86 percent of its steel consumption.[35] These indicators are valuable to the extent that they demonstrate the potential ecological

and resource consumption consequences of widespread industrialization in other parts of the globe. However, extreme caution should be taken when using them as indicators of "overconsumption" in the rich countries, for at least two reasons.

First, neither the rich countries nor the poor ones are homogeneous in economic terms. Few people in the industrialized world suffer the immiseration that is routine in much of the developing world, although that may well be changing, but their situation in terms of what they are able to consume is nevertheless sufficiently bleak that few of us would wish it universalized. Conversely, the Third World is not a homogeneous mass of impoverished people. "High-income households in Third World cities such as Lagos, São Paulo and Bangkok may have levels of non-renewable resource use comparable to high-income households in Los Angeles or Houston; it is the fact that there are so much fewer of them within the city population which keeps city averages much lower."[36]

The dramatic intra-city differences in environmental quality and the associated human health effects observable in those cities are a direct consequence of inequalities in the distribution of income and political power. Arguably, they are directly comparable to the differences in environmental quality and quality of life observed during the earlier stages of industrialization in what are now the industrialized countries. Indeed, intra-city differences in quality of life are becoming increasingly apparent in the industrialized countries as well, as illustrated by the return of tuberculosis as a public health threat and the Third World-style survival prospect for black men in parts of New York.[37] Such dramatic contrasts between wealth and poverty are likely to become more frequent as what Brian Berry calls "the global urban network" rearranges itself into a "polycenter organized by a limited number of complexes of multinational headquarters."[38] Such contrasts have no direct or necessary connection to ecosystem impacts, and are cited simply to make the point that aggregate indicators of any sort can mask tremendous differentials in how the impacts being measured are felt, and whom they hurt. An important component of knowledge about all such impacts is therefore "situated knowledge."[39] In addition, the preceding observations indicate a crucial limitation of averages and of indicators stated on a per capita basis, whether they refer to income, resource consumption, or anything else.

Second, the implication in much of the environmental discourse is that overconsumption of resources is somehow divorced from the provision of basic needs, which could presumably be met by activities using fewer resources and with more benign ecological impacts. This is conspicuously not the case in many poor countries, where (as the Brundtland report and countless other analyses have pointed out) people often destroy the environment precisely because there is no other way for them to meet the most basic of needs in the short term. Neither is it the case in rich countries. Many activities that are claimed to involve overconsumption of natural resources, according to whatever definition is being used at the moment, also provide employment that makes possible the meeting of basic needs. The options available to the people in question may be severely limited, and their access to livelihood contingent and transitory. Thus a job in tourism pays about one third as much as an average worker will earn logging the forests of Clayoquot Sound in British Columbia, and the multiplier effects associated with tourism employment are predictably less substantial.[40] Environmentalists might not like speedboats,

and might have an affective attachment to proposals to tax their production and use out of existence, but the distributional consequences implied by such a decision must not be overlooked.[41]

"Provocative Indicators"

The concept of a provocative indicator is drawn from a Seattle-based study of indicators of sustainable community, in which lists of indicators of sustainability under a number of general headings were originally divided into primary, secondary, and provocative. Examples of provocative indicators are:

- *Resource consumption:* the number of neighbourhoods where grocery store, general shopping, and mass transit station are located within three miles of each other; the revenues of appliance repair businesses and thrift stores (indicating a tendency to repair and re-use rather than discard).
- *Natural environment:* the ratio of pavement to planted area; acres of wetlands remaining in the particular jurisdiction in question.
- *Transportation:* the percentage of residents living within three miles of their work-places; average total cost, including time, of driving between various locations in the city as opposed to taking a bus; relative land area allocated to people and to cars, with the latter including not only road area but also parking lots, car dealerships, service stations, and so forth.[42] (I would add average traffic density, traffic speed and noise levels in residential areas, with particular focus on the ratios between these parameters as measured in poor neighbourhoods and as measured in rich ones.)

Devising provocative indicators is itself a worthwhile process, because the process of developing such indicators requires identifying competing conceptions of quality of life, and invites candid debate about them. It also exposes potential distributional conflicts, which means that almost all indicators may turn out to be provocative, whether or not that was the original intention. For example, rural or suburban lifestyles explicitly organized around avoiding the resource-consumptive dimensions of North American urban life would be unsustainable on almost any definition if all the people who aspire to them actually were able to try them. This phenomenon is best thought of as the *Harrowsmith* paradox. Who gets the opportunity to participate in such lifestyles, if they are widely regarded as desirable, is therefore a social and political question of some importance.

One of the clearest indications that human activity is not adequate to meet basic needs and maintain or enhance quality of life is the extent to which people are willing to incur considerable costs or risks to move elsewhere. Within cities, the frequently observed correlation between income and urban air quality allows the inference that, in terms of place of residence, cleaner is definitely thought of as better. Perhaps unfortunately for proponents of high-density urban settlement patterns on grounds of sustainability, better may also mean moving farther away from the city, and work, and from one's neighbours.[43]

Between nations, consider the fact that each year for the past several years, more than 1.2 million Mexicans have been arrested trying to cross into the United States illegally.[44] Dealing with the legally precarious and economically marginal status of illegal immigrants, and with increasingly aggressive enforcement efforts by the U.S. Immigration and Naturalization Service,[45] nevertheless was a more attractive option than staying where they were. Similar observations could be made about increasing

numbers of people around the world. The United Nations Population Fund recently warned that large-scale migration will be the price of failure to provide adequate economic opportunity for the 732 million people who will be joining the labour force in developing countries over the next 20 years. This number is larger than the *total* labour force in the developing countries as of 1990, and suggests the size of the economic development challenge that ultimately confronts the world as a whole.[46]

It is against this background that we should consider the growing literature on "environmental refugees," and on environmental and resource constraints as contributors to intra- and international conflict. As Thomas Homer-Dixon points out: "The term 'environmental refugee' is somewhat misleading . . . because it implies that environmental disruption could be a clear, proximate cause of refugee flows. Usually, though, environmental disruption will be only one of many interacting physical and social variables, including agricultural and economic decline, that ultimately force people from their homelands."[47] Large-scale migrations in Africa are among the most striking contemporary examples.[48] If the analysis of the linkages among poverty and environmental degradation provided by the Brundtland Commission and others are even partially correct, other examples are almost certain to follow.

The desire to change nation or region of residence, even at the cost of considerable hardship, is an extremely powerful indicator of what people prefer as components of quality of life. Much migration involves flight from political oppression and absolute privation. Among the many lessons of the Brundtland report is that, in the global context, both absolute and relative privation must be understood as political outcomes whether or not environmental damage is a contributing factor. If migration or the desire to migrate is to be used as an indicator of quality of life, and I would strongly argue for doing so, we must confront both the illusory nature of the line between political and economic asylum and the fact that for many people, much of the time, richer (according to the most conventional of economic criteria, the opportunities for consumption provided by high or rising money incomes) appears better. The indicator is thus provocative not only because it challenges many environmentalists' traditional disdain for the notion of a link between wealth and quality of life, but also because it unavoidably directs political attention to whether "the right to choose one's place of habitation on earth" should be regarded as a human right, as one commentator has suggested.[49]

Epilogue: Inside the Black Box

Hodge's suggested framework for sustainable development reporting is based on a truly prodigious research effort in which he examined literally dozens of conceptual models of the HEI.[50] Some are highly simplistic, consisting of little more than Venn diagrams with three partially overlapping circles labelled "economy," "ecology," and "society," or something of the sort. Others are highly complex depictions of the role of resource flows in an economy: the process Robert Ayres has elegantly captured in the term "industrial metabolism."[51] A basic weakness common to most such models is that they treat the actual process of decision making that determines the interactions between people and the ecosystem more or less as a black box. At best, reference is made to the information needs of different decision-making groups, without considering their relative ability (or inability) to do anything with even the best quality information, or

the potential adverse consequences to them of doing so.

This last point is why studying the incidence of costs and benefits of policies to achieve sustainability is so important, as has been shown with respect to the conservation of biodiversity.[52] For instance, tropical forest clearance is one of the most thoroughly studied human-induced stresses on the ecosystem, even if its implications are so far incompletely understood. Yet O'Riordan and Rayner point out that tropical forest destruction is still "addressed primarily as a management issue," rather than as the outcome of a complex set of inequalities in wealth and entitlements leading to widespread landlessness, one immediate social and economic cause of much forest destruction.[53] Even this is too simplistic a view: other authors point out that forest destruction can be traced directly to economic incentives and political initiatives on the part of governments, and the motivating force behind those incentives must in turn be understood with reference to governments' strategic efforts to reward supporters, enhance their own legitimacy, and avoid serious political unrest.[54]

Such sets of causal linkages are often more easily understood in other jurisdictions than in our own, but the lessons learned from studying them are important. It has been pointed out that: "we find in many instances, no economic forces whatever acting in favour of sustainable development of the biosphere."[55] It is often rational for all the actors whose decisions affect a particular HEI to "mine" forests and soils, to externalize costs, or to maximize returns from the use of common property resources. This is not necessarily the same as imputing to the actors in question a bias toward short-term planning of the type often associated with the high discount rates necessarily adopted by the poor as a survival strategy. It may be quite rational as a long-term strategy for poor individuals and national economic elites alike to liquidate natural capital and move on with the gains that result.[56] In a sense, this observation takes us back to the tension between weak and strong versions of sustainability referred to earlier in this paper. It also suggests the importance of looking at incentive structures. Who decides about them, and who benefits from them?

Would any amount or quality of additional information have led to a different set of policies with respect to the offshore Atlantic fishery? to a different combination of land uses in the forests of Clayoquot Sound? to the formulation of a transportation plan for the city of London, Ontario, that did not assume the inevitability of continued suburbanization and did not recommend more than $210 million worth of road widenings and extensions to meet projected travel demands that overwhelmingly involve private automobiles?[57] (The effect will be literally to cast in concrete a pattern of human activity that is unsustainable, by almost any definition.)

There is little reason to think that more and better information would have helped in any of these cases, and the issue of how sustainability is to be achieved is therefore more fundamental than implied by the routine assertion that incentive structures have to be changed. Even the most perverse incentive structures have their beneficiaries, often rich and powerful ones who have compelling reasons to resist precisely the changes that might be conducive to sustainability. Fierce resistance by ranch operators to limiting access to federally subsidized grazing lands in the western United States is a recent case in point.[58] Municipal transportation planning

efforts cannot be isolated from a political process routinely driven by the need to provide returns on speculative land investments that were made on the assumption that existing patterns of residential and commercial development will continue unchanged.

In addition, resistance is likely to be mobilized on the part of people whose livelihoods may be imperiled both by change and by continuation of existing patterns of human activity, yet who have few credible options without a radical change in the existing structure of endowments or rights to the use of resources. The plight of those who depended on the Newfoundland cod fishery for their livelihoods is an obvious example, as is the increasingly bitter conflict over logging and the future of the forest industries in British Columbia. This is not a counsel of despair, but yet another argument for designing sustainable development reporting in a way that will be helpful in answering difficult and troubling distributional questions.

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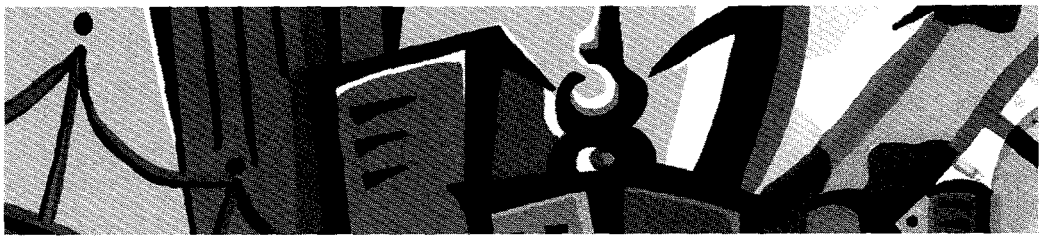


Proceedings

Commonplaces and Heresies about the Human-Ecosystem Interface

Presentation by Ted Schrecker

There are four central features that a system of reporting on the interface between humans and ecosystems should provide. They are the ability to:

1. assess sustainability based on a constant wealth criterion;
2. determine whether human activity meets sustainable minimum standards for ecological impact;
3. assess the costs and benefits of activities adversely affecting the ecology; and
4. provide a set of provocative indicators that will quantify the interface and reflect people's own assessments of their quality of life.

It probably is more useful to adopt a weaker version of sustainability, one that is not restricted to assessments based only on natural capital and that allows substitution of human-made for natural capital. There are many reasons for rejecting a definition that allows substitutability, but it is preferable, nonetheless, because it measures impacts in dollars, which can be easily understood and which can strengthen the case against the worst examples of resource mismanagement. Moreover, if a strong version of sustainability is used it creates its own, even more substantial, problems. Consequently, adopting substitutability and a constant wealth criterion is a necessary, but not a sufficient, requirement for achieving sustainable development.

A constant wealth criterion could be bolstered with sustainable minimum standards, especially in cases of uncertainty or incomplete knowledge. Such an approach would be preferable to adopting a "precautionary principle" that linked approval for activities to presumptions regarding impacts on human health. A "precautionary principle" is meaningless without a commitment to forestalling harmful activities at any cost, which can be totally irresponsible. Sustainable minimum standards would permit a balancing of objectives in the human-ecology interface.

In addition, a constant wealth criterion would permit a more realistic assessment of impact for exporting, as well as importing, countries. This could be a distinct advantage in drawing ecological footprints, especially

if sustainability is defined to include sociological issues, since the footprint would be greatly widened.

There are extremely serious problems involved in quoting indicators in per capita terms, such as in steel production or resource consumption. Populations are not homogeneous and the indicators can be deceptive. Moreover, there are aspects of production that are insupportable if judged in terms of human rights or environmental need. Nevertheless, any production will be providing people with incomes. Caution, therefore, is advisable, both in using per capita figures and in assessing impacts.

Provocative indicators are extremely useful in illuminating complex relations among ecological impacts, economic activity, and quality of life. Most are local, such as traffic speed in residential areas and the ability to live close to work. But some are regional, such as population migrations.

Response

Synopsis of Response

There were measures of agreement in most of the areas touched on in the discussion of Mr. Schrecker's paper, so much so that had there been an effort to reach consensus on where to focus and what to prioritize, the effort probably would have been successful – although consensus on implementation would have been more difficult. The most serious disagreement would have been on how to implement value change. The division was between those who advocated promoting value shifts as a means of promoting sustainable activity and those who saw value change as flowing from changes in activity. All agreed that fundamental changes in values were necessary.

There also was broad agreement that reporting systems based on precepts of neoclassical economics are inadequate and misleading. And, although there was complete agreement that traditional approaches to economic and financial analysis have a role to play in decision making, there was wide disagreement about how prominent a role that should be. With one or two exceptions, participants thought there was merit in a weak sustainability criterion combined with minimum standards, but again there was no evident agreement on how large a role it should play among the various tools for promoting sustainability.

As one participant put it rather succinctly, "Everyone seems to be saying 'I agree, except where it impinges directly on me'." He argued that there should be an attempt "to move on where we agree instead of discussing points on which we disagree." However, participants preferred to engage in a free-wheeling discussion instead of channelling their efforts toward identifying specific points of agreement.

Overall, it was apparent that the interaction domain was an area familiar to participants and one where they could readily apply the expertise of many disciplines.

Critique

(An extensive formal critique of Mr. Schrecker's paper was undertaken by Prof. William Rees. The critical remarks that follow are all his, except as otherwise noted.)

The notion of weak sustainability is based on a preference for economic criteria. However, to assert that notion is to argue against oneself. No longer is there a division between the human and the ecological. The

human animal, in supplying its own needs, has merged its economy with the ecosphere. We are still using the Cartesian dichotomy of humans and the ecology. The material and energy information flows within nature, and the material and energy flows within human affairs, are now really the same thing.

In economic models, the starting point for analysis is the circular flow of exchange value. By contrast, if the starting point for analysis becomes the physical reality of energy transformations – in other words, the thermodynamic relationships that are the essence of any ecosystem and of all human activity – then we begin with a first principle that says an economy is sustained entirely by low-entropy energy and matter that is produced "externally" by ecosystem and biophysical processes. As a result, all economic production is actually consumption; ecologically relevant material and energy flow one way and irreversibly through the economy. There is no circular flow.

Understanding thermodynamic flows is absolutely necessary for connecting the economy to the environment. Consequently, we run into great difficulty when reliance is heavily placed on economic factors.

Moreover, economic models are based on the assumption that market pricing works. But does it? We must have food, but to have food we need an ozone layer. One of the necessary criteria is that we must sustain a minimum ecological system. However, how do we put a price on ozone? Fifteen years ago, no one paid any attention to it, so we did not know its value until we violated the boundary. What we demonstrated is that it is impossible to price things like ozone in advance.

What we must recognize are the limits of rationality. We are not going to be able to measure our way into predictability. Chaos theory ought to illustrate that. We cannot understand nature completely, nor can we build reliable models. That whole vision of how to handle things is crumbling, especially as we approach limits. There are disequilibrium points that rule out relying on old models.

A constant wealth criterion cannot address these uncertainties because of its reliance on income flows. All we have in the end is a measure of potential sustainable income. And we will still have the problem that there may be depreciating capital that cannot be measured in any event.

Money is a metaphor for real wealth, but it has properties distinct from the biophysical assets that it represents. For instance, it can grow indefinitely while real wealth may remain static.

At this point, Mr. Schrecker interjected to ask whether behaviour in the past would have changed if there had been better information on ecosystem relationships.

Prof. Rees replied that there was a good chance there would have been no change. As a result, the search for a better indicator often ends up being a search for a better thermometer – and that does not necessarily make for better decision making. What we have to recognize is that unless there is a fundamental shift in values and expectations, "it ain't gonna make any difference."

In the past, we used growth as the measure of progress and it turned out to be misleading. And in the current situation we do not talk about redistribution because it is politically suicidal. Within the current paradigm, if the wealthy see themselves as threatened, their response is swift and certain.

The whole rhetoric of globalism is self-defeating: "hone your competitive practices," "maximize your returns." It is like putting scorpions in a bottle. We end up destroying our resource bases. What we need is a new

paradigm, one that emphasizes co-operation, not competition; that stresses social capital, not private capital. In a half-joking way, Prof. Rees offered some indicators that he thought would be revealing, such as an index of neo-classical economists who recant; the number of requests by communities to government asking that their grants be cut back because they were doing their jobs without grants; and the rate of substituting a calculation of social carrying capacity for appropriation of carrying capacity.

Mr. Schrecker agreed that, standing alone, a weak sustainability criterion was insufficient to determine whether activities are sustainable. However, it was not inconsistent within the paradigm. The market will show a high price as a resource is running out. So the real measure of capital assets is the value of the income stream from them.

There was an internal consistency, Prof. Rees agreed. Any model is consistent by definition. His emphasis, however, was on the important points that lie outside the model:

1. if we want to manage a system, it must have the same internal variety as the model we are trying to manage; and
2. if we cannot get prices right, the model does not mean a thing; what happened in the north Atlantic cod fishery is a prime example. Prices gave no indication whatever of the imminent collapse.

Prof. Robinson noted that as soon as we start talking about values, people see them as secondary. Setting a value framework can be an imperialistic exercise. He would resist trying to set up a primary framework into which everything has to fit. It is wrong to assume absolute primacy.

He was not saying there was no inequity, Prof. Rees replied, only that there will be no change in inequity without a change in values. We must have a change from the exhortation, "thou shalt be a utility maximizer," toward a value shift that makes us recognize that there is more benefit to be had through community co-operation.

Prof. Robinson said that he liked the notion of a weak sustainability criterion because it allows substitution; what he did not like about it is that it does not, in itself, offer a sufficient measure of sustainability. However, he was attracted by Mr. Schrecker's proposal that a weak sustainability criterion be used on the accounting side and that tough restraints be used on the environmental side. That was an exciting prospect.

Commentary: Making Observations, Posing Questions

This is not the time to eschew rationality, but to look at what is called second-level science, which deals in areas where there are uncertainties. If rationality is defined solely in conventional terms, then there can be little argument against turning away from it.

Regardless of whether we are talking about linear or non-linear systems, we can still have a rational approach. The crux of the issue is maintaining natural capital in the course of activities. What we should be doing is looking at the quantity of natural capital that has to be conserved in order to determine how much we can consume. We should be measuring stock and how much of it we are taking out. We should not be trying to add into national accounts the increase in value of depleting natural assets. It does not work.

The idea of "zero" as a safe minimum standard is certainly required in some instances, for example, in the case of persistent toxic substances. Prof. Rees is quite right in pointing out that we have to deal with realities, and

persistent toxins are one of them. Also attractive are his efforts to bring social carrying capacity into the concept of private carrying capacity.

We are not managing natural systems; we are managing human activities. When Prof. Rees suggested as an indicator the number of communities asking governments to cut back on grants, one participant was reminded of a Nova Scotia community that had no doctor because no grant was available. In the end, the community donated land, built a clinic, and hired a doctor. It was a good indicator for the health and sustainability of that community.

Monitoring stock is one of the essential focuses of reporting. However, we have to do something about stress. We have to be reporting back to decision makers about what we are doing to stock. We are constantly measuring flow and that is probably the reason why we have never made the connection to stock in national accounting systems. Call it wealth, or assets, or whatever you want, but in accounting terms stock exists at one point in time, while flow exists in two points in time.

Despite the seriousness of the disappearance of the northern cod, we have very little information about what happened. Nevertheless, their disappearance offers an opportunity to test indicators. If we find indicators that would have worked to warn us of what has happened, then those indicators will be worthwhile.

Sustainability reporting should be at arm's length so it can report on governments and institutions and other powerful bodies in society.

Mr. Schrecker responded that, if this plea for arm's-length reporting is to be taken seriously, someone will have to pay for it. Scientific or professional activity is never truly independent of its source of funds.

It is disturbing how money measures are sometimes dismissed as not being useful, another participant said. The financial status of a family, for instance, is important in determining its sense of social security. Accounting can provide helpful support to management decision making. But do not look to academic economists; look to the Ernst and Youngs.

On the other side of that coin, it is necessary to stress that all of our solutions are partial. The paradox is that we live in a system where economic indicators are seen to be the be-all and the end-all.

There is no such thing as cool reason. Our reason is always emotional. Look under reason and you will find emotion. So maybe we should develop an index of primal emotions covering such things as anger, abandonment, and fear of death. Understanding emotions will give us a better understanding of the actions that flow from them.

There are three basic functions for reporting:

1. providing feedback for decision making;
2. identifying what is going on in the real world; and
3. image building or, in other words, creating the image of whether the ecosystem is well or badly off.

We have had a massive increase in information, but no comparable increase in insight. Gunnar Myrdal points out that there are no scientific truths in the social sciences; there is only more or less relevant information. And this raises the question: what is relevant information?

Discussion: Offering Suggestions

At this point, the discussion gradually centred on four categories of needs, which can be characterized as relating to information, state-of-environment reporting, values, and judgment.

Suggestions Concerning Information

The thrust of Mr. Hodge's paper with its four indicator domains is, in effect, a plea for simplicity and that, in itself, is attractive. However, almost everything is increasing at an exponential rate. Knowledge is not increasing that fast but data is. And the scale of human enterprise matters now whereas it did not 100 years ago. It is only since we have become capable of blunders such as depleting the ozone layer that we have needed more data. But even when we have more data, no one knows how to deal with it. Any system that requires a large number of inputs is limited by the ability to add the smallest input. So, at any one time, the absence of only one input can derail the system. How, then, do we reduce the range of inputs so that we know we are dealing only with key variables? We need to know what the linchpin variables are – the ozone layer, for example, the loss of which can bring down the system. And we need to know who the key decision makers are. We will have to tune the data to the needs of decision makers. And we need to bear in mind that Canada cannot be sustainable in isolation, so interdependence is necessary.

It is not new information that is important, it is movement to action on existing information. The information on tuna stocks is more enlightening than that on cod stocks. Something disastrous is happening; however, it was not until 1993 that action on tuna got started.

What we need is an information strategy that minimizes the information needed, maximizes the decision making power, and is cost effective.

Information has to be communicated in simple terms so that the media can deal with it. (We could well do with a "Ten Commandments" of sustainability, with one set of ten commandments for each element of society that has a significant impact on sustainability.)

For information to be understandable, it has to be specific. It has to deal with your town and your income.

In the context of this colloquium, a discussion about information raises the question of the role of the National Round Table. Is its role only to gather more information? We already have plenty of information; the problem is that we do not act on it. It would be far better for the National Round Table to concentrate on identifying key indicators. To put it another way, the National Round Table could be most helpful if it were to focus on linchpin indicators that would link:

- livability;
- sustainability; and
- equitability.

Even though we do not have a full understanding of methodological approaches, we should press ahead and do what we can to address problems that we already know about.

It would be worthwhile to compile a database on ecological footprints, for instance, on the ecological footprint of importing goods such as tropical timber. And if the National Round Table wants to contribute to making the debate more honest, it should take two or three years to determine whether the rest of the world can realistically expect to reach the standard of living of the industrialized world.

The simple fact is that we need more information simply because the problems we have now are problems of scale, whether we like it or not. But we cannot get all the information we need and therefore we have to make choices. Consequently, the critical issue is whose criteria do we use to make these choices? Otherwise we will be operating

according to the Titanic School of Management: we will be deciding whether those in steerage should share meals in the dining room, when we [the National Round Table] should be on the bridge and shouting: "Iceberg!" Perceptions matter a great deal. But there are facts to face. If the ship is sinking, the ship is sinking.

Who should decide? That is the real question. We have a great need for state-of-environment reporting, but we need to go a long way beyond that in the direction of interpretation. Those involved in state-of-environment reporting cannot provide high-level interpretation.

The real audience is the public. Forget the high-profile decision makers. The public is not just the audience, its members are the interpreters. So, we should give them the means of interpreting. In other words, we should give them ranges of interpretation, and tools for choosing. In the process, we should not forget that there are many publics, many backgrounds, and many cultures. So when we speak of sustainability reporting, we should think carefully about how to address these many publics.

Suggestions Concerning State-of-Environment Reporting

According to one viewpoint, there is no disparity between the goals and objectives, the perspective, and the values expressed in Mr. Hodge's paper and what has been embraced by state-of-environment reporting. It is difficult to see any difference between what Mr. Hodge is proposing and what federal state-of-environment reporting is trying to do on human health. Federal officials have invited health experts to approach issues in a more holistic way and to co-operate with them in expanding state-of-environment reporting. We have to start small before we can start big.

From another viewpoint, there is a significant difference between the two. State-of-environment reporting has found itself backing into dealing with the economy and with human health. In the case of health it is doing so because of the existence of contaminants in the environment. But there are whole sets of people looking at health and well-being who are not even thinking about state-of-environment reporting, such as people dealing with immigration. They are concerned with health and well-being issues in their own right and not because they are an afterthought or an extension of state-of-environment reporting. There is also the basic question of how we effect an integrative function within a federal government that is divided within itself. The conclusion of the National Round Table is that it is not possible within one federal department to achieve the kind of synthesis and exchange of information that is necessary.

Suggestions Concerning Values

Everyone at this colloquium has assumed that there is a need for a greater or lesser shift in values, and it seems that a value shift has started. The challenge is to nourish this shift.

It was said earlier that we are managing people, not the ecology. However, the reality is that there is a perception that we are doing things that will respond to impacts on the environment. We are doing some things, but technical solutions will never be enough or be adequate. In the case of the northern cod, we have dealt with stocks and prices and quotas, but we have ignored behaviour. Until we start focussing on the roots of behaviour we are not going to get anywhere. Simply parsing action into emotion and rationality is not satisfactory. Whatever depends on emotion cannot be measured and, hence, is irrational. Rational

is defined as being capable of being measured, but even that model is fraying at the edges. If we are ever going to convince people to shift from their given value sets and persuade them that they need to care about other species, it will have to be on the basis of enlightened self-interest. Perhaps we can achieve that shift if we show them that their survival depends on it. In any event, there is no evidence that this value shift is under way. There is a fundamental dysfunction between how we view the ecosystem and how we act toward it. Yet there are certain fundamentals that have to be observed. For instance, if we are building an aircraft, we need to pay attention to gravity and to friction. Whatever politics or ethics are operating, there are similar fundamentals that have to be observed. Not every country can run a deficit with regard to ecological inputs. In reality, however, everyone is on the global development path and so everyone is engaged in the same rapacious behaviour. The current demands of countries already are unsustainable. That is the fundamental reality that we have to deal with.

Another participant suggested that the airplane metaphor misses the point: we are not talking about ignoring gravity; we are talking about asking what gravity is. Information alone does not necessarily affect behaviour. It may affect attitude, but attitude does not necessarily alter behaviour. For instance, we can have a proper attitude but our behaviour can remain unchanged, and that can be for many reasons, one of which is income. If we want to change behaviour, we have to address behaviour. There must be a fundamental restructuring that will minimize the use of energy and matter. There is also a need to address a deindustrialized future, which will bring much more inequity if there is not, yet again, a fundamental restructuring.

Ontario Hydro commissioned a study on changes in the Ontario environment. It found that most areas in the province were degrading and that degradation was most severe in southern Ontario. Degradation varied according to the density of human settlement and activity. The response was, "So what are you telling us? That economic activity is bad?" Regardless of the answer to that question, the reality that we have to deal with is the degradation.

In building an indicator system, we need to include something for people who are motivated by emotion. Eventually, we could think of a weak sustainability criterion as an interim means on the way to a major value change. However, these things do not happen in linear progression. What we need is a diversity of indicators in order to address different publics.

The kaleidoscope is a useful metaphor because it speaks to diversity, not only in the ecology but in public attitudes and practices. It also speaks to the likelihood that no single approach will be sufficient. How do we make the connection between what is going on in this colloquium and the people at large? Do we really need to capture the imagination of people? Must we accept the proposition that all we can do is change behaviour now and value change will come later? What are values? An exposition of values is not the same as a coherent philosophy. Mr. Hodge speaks of Prof. Rawls and overlapping consensus; can we marry ecological imperatives to that? What about freedom from arbitrary arrest? Or rights and freedoms? Are they as basic, or less basic, or more basic, than preservation of planetary systems?

The problem facing us is that we cannot wait for a major value change. If we had waited for such a change in relation to acid rain we never would have got anything done.

We should not be fighting people's short-term interest; we should be tapping into it. Setting sustainable minimum standards seems a good way to go.

There may be an argument as to whether there is a value shift under way. But what if we assume that there is? What implications does that hold for a reporting system? If we work on the assumption that it is under way, should we not be trying to establish a reporting system that can encompass and reflect and enhance that process?

There remains a strong focus on the state and the expectation that it will lead the way to solutions. However, we have to be thinking about different ways of doing things. We ought to be looking at the factors that create change, and when we do, we find that:

- increased security equals increased equity; and
- action change precedes value change.

We also need to look at institutions and examine the way in which they change values and practices. However, that will necessarily involve criticism.

It is always necessary to remember that indicators are simply one tool among many. Their role is to help in the making of judgments. And as different decision makers have different needs, so we will need different indicators, or indicators that can serve different roles. Just to underline the complexity we face, the word "social" has about five different meanings in theoretical usage. So to get at common elements, we need to get under the language. And to do that, we need to realize that the motor of the system is human activity.

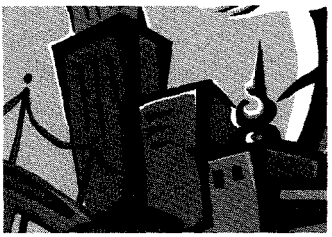
Suggestions Concerning Judgment

State-of-environment reporting cannot do all that Mr. Hodge is proposing in his paper. There is much data but little synthesis. For example, look at what is happening on the west coast. There is a hodge-podge of facts, but they do not tell us whether the ecological situation is getting better or worse.

The Baie des Chaleurs area is a good example of our inability to synthesize. The shore is lined with beautiful fishing villages that have no fishing boats and no fish. Yet this was once one of the richest salmon fisheries. The fishery was destroyed in the 1950s and 1960s and was closed in the 1970s. The fish never returned. Yet the signals of impending disaster had been apparent for a long time. Two of the practical questions that need to be answered are: who should do the reporting on sustainability? and how much assessing of progress cannot be done within a line department of government?

A good definition of decision makers is that they are people who have money and freedom to use it.

A reporting system by itself is sterile. Information needs to be placed within the context of an action plan so that it will be possible to have a sense of priorities. And, needless to say, any action plan needs to be well publicized.



Ecosystem, Interaction, ***People***, Synthesis

The focus of Ms. Holtz's paper was the third of the four indicator domains identified by the National Round Table as providing the basis for a system of reporting progress on sustainable development in Canada. This domain deals with assessing the well-being of people according to wide-ranging criteria.

Approaches to Reporting on Human Well-Being

By Susan Holtz, Vice-Chair
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Introduction

Let me start with a disclaimer: I am well aware that, from the perspective of experts in the numerous disciplines I will be dealing with, my knowledge of the relevant research in the fields that I address is superficial. In researching and writing this paper, I was constantly afraid that I was just not going to know about some obviously key piece of work, and I would thus produce a deeply flawed analysis and look like a presumptuous fool, to boot. Nevertheless, I persisted in the task. Despite my limited expertise on the topic of human well-being, I did feel reasonably confident about the amount of thought, discussion, and practical experience I had concerning reporting related to sustainable development. And that, I would emphasize, is the focus of this article: not human well-being as a field of research for a multitude of disciplines (which it is), but rather, human well-being as one of the essential domains of information needed to report on progress on sustainable development (SD or, in some contexts, sustainability).

What are these key domains of information? I do not want – in this article, at any rate – to argue for the conceptual framework for reporting on SD that I and others at this colloquium are using. There are other frameworks, and most are useful in the context for which they were developed. The information domains framework used here is not a dynamic model, but merely a description of the broad categories or domains of information that are common to most concepts of SD found in the literature (Hodge 1992). These categories include information on the health or well-being of the ecosystem; information on human well-being; and information on the interactions and human activities that affect, and are affected by, the ecosystem that encompasses and supports human societies. As well, in reporting on SD, a contextual review or synthesis of all these information domains is needed in order to consider the various linkages among them.

I would note two things here. First, these domains of information are derived from the values that inform the idea of SD: specifically,

a valuing of both human and ecosystem well-being, neither to the detriment of the other, but both together. Thus there are value judgments built into the very fabric of SD reporting, and these may well make cross-cultural comparisons difficult. I think this is particularly the case in reporting on human well-being.

Secondly, although human beings and the surrounding ecosystem are treated as separate domains of information, this is a practical, not a philosophical, distinction. In reality, humans are as much a part of the ecosystem as eagles or dogs or nematodes. However, the SD reporting context is one that implicitly focusses on information needed to better manage human activities, both for human well-being and for the maintenance or restoration of healthy ecosystems. Consequently, information categories are used that are relevant to decisions related to these goals. Nevertheless, as we will see, many of the approaches used in reporting on human well-being reflect the fact that individuals live in the environment, and their well-being cannot – even conceptually – be disentangled from their physical environment, nor their physical environment from the social and economic environment.

Why use the term "human well-being" and not some other term, such as health, happiness, human development, or quality of life? The term "human well-being" is taken from Tony Hodge's work (Hodge 1994). It was adopted by the Task Force on Sustainable Development Reporting of the National Round Table on the Environment and the Economy. This Task Force has been working over the past year and a half on a report to the Prime Minister of Canada on this country's capability to measure progress on sustainable development. The term is intended not to replace the many other related words and phrases but as a generic term that – in the context of SD – contains the essence of the variety of terms that have evolved in other contexts but clearly have a relationship to SD.

As I will discuss, many of the relevant disciplines have spent considerable effort on refining the definition of the term they use (health is one example). By contrast, I am going to spend no time at all defining human well-being. My assumption in this paper is that all of the approaches I am going to discuss have different perspectives and insights to contribute to SD reporting. What I will do here is, first, try to identify overlaps, differences, and unique insights in these various approaches to human well-being, and, second, consider the issues that arise when we juxtapose the other domains of information with human well-being in the synthesis of human and ecosystem well-being that the concept of sustainable development represents. In other words, I will look at the linkages between these approaches to reporting on human well-being and reporting on ecosystem health and human activities.

Disciplines, Definitions, and Discussions

Six Approaches to Human Well-Being

In this paper, I will review six approaches to describing and reporting on human well-being. These are:

1. economics (especially income/wealth);
2. health;
3. quality of life (QoL);
4. politically developed collections of targets (called here targets, benchmarks, or societal objectives);
5. human (societal) development; and
6. happiness (or subjective well-being – SWB).

Each of these approaches has developed in a distinct context. For some, such as economics and happiness, there are specific, well-established academic disciplines that surround the concept and that tend to confine ongoing development of the idea within the boundaries established by the academic discourse. For others, such as human development and the targets approach, the context is the development of public policy, and so the discourse is open to any interested commentator. All these approaches are characterized by considerable overlap in substance, but little in the way of deliberate attempts by researchers to synthesize or harmonize – or even, in many cases, to recognize – different but related approaches from other contexts.

Finally, in this preliminary sketch of the field, there is the relationship of each approach to the overarching framework of sustainable development. This varies widely. Except for the human development and the targets approaches, all of these approaches were "born" prior to the (relatively) widespread use of the SD concept (which I would date here from the World Commission on Environment and Development – the Brundtland Commission – report *Our Common Future*, which was published in 1987).

Nevertheless, some of these approaches are consciously seen by their practitioners or SD researchers as being critically related to SD reporting, possibly as being the preferred or even the exclusive approach to the human well-being dimension (health and economics, for example). Other researchers, especially in QoL, seem to be struggling to bring the concept of SD into their own discourse. In contrast, the targets approach, and probably human development as well, are seen by those involved in their development as natural relations or outgrowths of SD thinking and reporting. And happiness research, which began in the early to mid-1970s but has grown enormously since then, is done by academic researchers mainly in the field of psychology, most of whom, even very recently, appear either never to have heard of sustainable development, or else consider it professionally irrelevant.

Description of the Six Approaches

As a preface, I would note here that these six approaches are a somewhat arbitrary number. Some could be further subdivided into other categories, or re-combined. Above all, I do not discuss the discipline of philosophy/ethics/practical ethics, which has a great deal to say about human well-being, going back at least to the classical Greek philosophers. Nor do I consider religious and spiritual insights. Apart from their lack of universal acceptance, the main reason I ignore them here is that both religion and philosophy are more about approaches to life than about components or determinants or states of well-being that can be measured and reported. As specific approaches, they are therefore not directly useful in the context of SD reporting, although both perspectives inform and are intertwined with the foundations of all of these other approaches.

Economics, of course, needs no introduction. Traditional economic models deal with "maximizing welfare" and virtually all the literature on SD assumes the need for income in order to meet human needs, and, in particular, the urgent need for increasing the incomes of the world's poorest people.

The question here is not whether economic measures, such as income, wealth, debt, and gross domestic product (GDP), have a place in describing human well-being – of that there is no doubt – but rather, whether these measures are sufficiently powerful components, or determinants, or proxies for human well-being to be used alone.

I do not think they are. But before moving on, I will pursue this line of thought a little further.

To start with, there is the familiar observation that, in describing national economies, standard approaches to a system of national accounts (SNA) do not incorporate losses and damage to the stock of natural resources, or to the "environmental services" provided by a healthy ecosystem. Similarly, some have argued that "defensive expenditures" for environmental security should be subtracted from income accounts to better show the significance of a healthy environment in economic terms. However, considerable work is ongoing in various organizations, such as Statistics Canada, the World Resources Institute, several Organization for Economic Co-operation and Development countries, and the United Nations, to find ways to better incorporate these factors in national accounting. If and when these efforts become standard practice, will these adjusted national accounts suffice to describe human well-being at the national level?

In describing individual well-being, income is powerfully linked to many other aspects or approaches to well-being. A very strong positive link between health and income exists (Hancock 1989), though we need not here concern ourselves with the argument about which is cause and which is effect. There is a similar positive correlation between self-reported well-being or happiness and income, though there are many complexities, including diminishing returns in happiness for ever-higher levels of income (Myers 1992).

There is also negative evidence, that is, evidence about issues of well-being that are related to lack of income. In a major recent study of the causes of homelessness in the United States, although there are several secondary factors (a situation of social isolation and disability in the form of chronic physical or mental problems and/or addiction for the long-term homeless), the single dominant factor is destitution – an income level greatly below the poverty line (Rossi 1989). More negative evidence comes from another study that attempts to unravel why the increasing productivity of the U.S. economy since the late 1940s has been translated entirely into higher incomes for workers rather than more leisure time (indeed, leisure has declined since the 1970s), when either could theoretically be equally possible. The productivity growth has been such that U.S. workers could now be working four-hour days as full time, or taking every other year off with pay. The author is mainly interested in structural reasons, but nevertheless notes a deep resistance on the part of workers themselves to trading current income for more free time; however, the same is not true for hypothetical future increases in income versus time off (Schor 1992).

It could be argued, from this diversity of evidence drawn from many disciplines, that income has such a robust relationship to well-being that, for reporting purposes, it could effectively capture well-being. Additionally, it would be a simple, cheap, easily comparable, and already collected statistic. Although I think this is a credible argument, I do not agree with it; nevertheless I will put it aside until I examine some of the other approaches.

Health is another apparently obvious approach to well-being. Indeed, in its denotation in ordinary English, health perhaps comes closest to meaning "well-being." However, in the context of SD reporting, developments in the last decade in the field of health promotion have moved the definition of health away from its traditional meaning as an absence of pathology to a more contextual focus. A major conference in 1986, sponsored by the World

Happiness or subjective well-being (SWB) is my last category. As a research field, it too grew out of the QoL/social indicators interests of the 1970s, but it has developed intellectual momentum only since the 1980s. Its researchers are mainly drawn from psychology, and its focus is on the relationship between various factors or determinants of well-being, and the actual assessment individuals make of their own state of well-being or happiness. Health, income, relationships with others, education, and demographic factors such as age or ethnicity or gender have all been scrutinized. Distinctions between temporary moods and overall life satisfaction or personal well-being are examined. And related questions are posed, such as whether some factor related to happiness, such as wealth, is important in itself, or as a comparative measure with other people. Perhaps one of the most interesting of these related issues is the finding reported in a number of studies that dissatisfaction or "ill-being" is not at one end of the continuum with well-being, but is a separate dimension of experience (Headey et al.1984). The findings and debates in much of this field are all interesting, particularly in view of the light that is shed on other approaches to human well-being in the context of sustainable development.

Some Fundamental Lines of Cleavage

The first question to which these six approaches provide different answers relates to the unit of humanity whose well-being is under discussion. In SD reporting, are we fundamentally considering the well-being of individuals? Do we want to consider the smallest significant decision-making unit, the household? Or do we want to focus on groups or whole societies, using averaging of individual or household experience rather than categorizing different kinds of individuals?

Of course, the easy answer is that different units may be appropriate depending on the scale of the geographic region for which SD reporting is being established. But that may be too easy. There remains a real question of focus: in SD reporting, are we mainly interested in characterizing individuals, households, or the society as a whole, or in some combination?

Of these six approaches, economics is the most flexible. Economics is capable of describing individuals, households, groups, and whole societies with ease. This, of course, is because it is the only approach with a single, standardized unit of measurement (dollars) that can be applied to the income, wealth, debt, and so forth of any person or group. (The tradeoff, equally obviously, is that economics can only describe those things that can be measured in dollars, or for which dollars can be a proxy.)

Two of the approaches, health and happiness, are basically about assessing the well-being of individuals. Although one can speak of a healthy or a happy society, these are really metaphors, not literal statements. It is individuals who are happy or healthy, and although it is certainly possible to add up numbers of individuals who are happy or not, or who are afflicted with some ailment or condition, the unit being described is the individual. The only exceptions that I can think of are life spans and measures such as worker-days lost; again, although related to health, these employ standardized numerical measures, and thus can be averaged to directly compare groups or whole societies.

The remaining three approaches are about describing conditions of society more than individuals, although there may be an implicit assumption that the ultimate reason to report on these things is because they affect individuals. The authors of the UNDP *Human Development Report* series state that "human

developed 160 measurable targets for the state; from this full list, a shortlist of lead benchmarks was developed to set priorities for the next five years. These included seven benchmarks for people: teen pregnancy; kindergarten readiness; drug-free babies; drug-free teens; job skill preparation; hate crimes; and work force adaptability (i.e., re-employment of displaced workers). There were five lead benchmarks for quality of life, including such things as air quality, affordable housing, and health care access. And there were five lead benchmarks for the economy, including value-added wood products, the tax burden, and public infrastructure investment. As well as this list of immediate priorities, the project shortlisted 13 key benchmarks as fundamental, enduring measures of Oregon's well-being; these included measures of health and literacy for people; environment, housing, health, and crime measures for quality of life; and personal income, industrial economic diversity, manufacturing exports, and job distribution in the state outside the Portland metro area for economic measures.

At this point, there are almost too many examples of this approach to keep track of. Some exercises have been led by round tables, such as those provincial SD strategies that include specific goals and objectives. Municipal examples include the "Sustainable Seattle" indicators project and "Life in Jacksonville: Quality Indicators for Progress," a project led by the Jacksonville (Florida) Chamber of Commerce and the Jacksonville Community Council Inc. In all cases, however, the focus is not on researchers developing accurate indicators, but on communities or other political jurisdictions developing their idea of appropriate measures and goals for well-being.

Human (social) development as an approach also has much in common with QoL and social indicators research, but where QoL is concerned with place, human development is concerned with social and economic development from the perspective of international development aid. Its implicit research question is whether things are getting better or worse in developing countries relative to each other and the developing world, and for special groups within countries, such as women or children.

The best-known and probably the most influential example of this approach is the annual *Human Development Report* series, which has been published since 1990. (Indeed, so comprehensive and intellectually powerful is this report that I wonder whether it will not gain currency as the accepted major international measure of human well-being.) This project is organized by a team from the United Nations Development Program (UNDP). Each yearly report discusses different aspects of human development, but each one also publishes a standard set of statistical profiles and indicators for all countries, and – perhaps most importantly – a human development index listing for all countries.

The index, here referred to as the Human Development Index or HDI, consists of a weighted average of just three factors: longevity, measured as life expectancy at birth; educational attainment in terms of adult literacy rate and mean years of schooling; and income. The income measure has been revised since 1990, and in the 1993 report, the indicator used is real per capita GDP in purchasing power parity dollars. The authors recognize that there is diminishing utility to ever-higher levels of income from a development perspective, and have tried various technical measures to make this adjustment; they are not yet entirely satisfied with their conceptual approach.

The HDI also displays country listings that have been adjusted to take gender parity into account.

Happiness or subjective well-being (SWB) is my last category. As a research field, it too grew out of the QoL/social indicators interests of the 1970s, but it has developed intellectual momentum only since the 1980s. Its researchers are mainly drawn from psychology, and its focus is on the relationship between various factors or determinants of well-being, and the actual assessment individuals make of their own state of well-being or happiness. Health, income, relationships with others, education, and demographic factors such as age or ethnicity or gender have all been scrutinized. Distinctions between temporary moods and overall life satisfaction or personal well-being are examined. And related questions are posed, such as whether some factor related to happiness, such as wealth, is important in itself, or as a comparative measure with other people. Perhaps one of the most interesting of these related issues is the finding reported in a number of studies that dissatisfaction or "ill-being" is not at one end of the continuum with well-being, but is a separate dimension of experience (Headey et al.1984). The findings and debates in much of this field are all interesting, particularly in view of the light that is shed on other approaches to human well-being in the context of sustainable development.

Some Fundamental Lines of Cleavage

The first question to which these six approaches provide different answers relates to the unit of humanity whose well-being is under discussion. In SD reporting, are we fundamentally considering the well-being of individuals? Do we want to consider the smallest significant decision-making unit, the household? Or do we want to focus on groups or whole societies, using averaging of individual or household experience rather than categorizing different kinds of individuals?

Of course, the easy answer is that different units may be appropriate depending on the scale of the geographic region for which SD reporting is being established. But that may be too easy. There remains a real question of focus: in SD reporting, are we mainly interested in characterizing individuals, households, or the society as a whole, or in some combination?

Of these six approaches, economics is the most flexible. Economics is capable of describing individuals, households, groups, and whole societies with ease. This, of course, is because it is the only approach with a single, standardized unit of measurement (dollars) that can be applied to the income, wealth, debt, and so forth of any person or group. (The tradeoff, equally obviously, is that economics can only describe those things that can be measured in dollars, or for which dollars can be a proxy.)

Two of the approaches, health and happiness, are basically about assessing the well-being of individuals. Although one can speak of a healthy or a happy society, these are really metaphors, not literal statements. It is individuals who are happy or healthy, and although it is certainly possible to add up numbers of individuals who are happy or not, or who are afflicted with some ailment or condition, the unit being described is the individual. The only exceptions that I can think of are life spans and measures such as worker-days lost; again, although related to health, these employ standardized numerical measures, and thus can be averaged to directly compare groups or whole societies.

The remaining three approaches are about describing conditions of society more than individuals, although there may be an implicit assumption that the ultimate reason to report on these things is because they affect individuals. The authors of the UNDP *Human Development Report* series state that "human

development is a process of enlarging people's choices." In discussing exactly what the HDI measures – quality of life, standard of living, or happiness – the authors comment, "But if human development is a process of expanding choice, there can be no limit. . . . The index is best seen as a measure of people's ability to live a long and healthy life, to communicate and to participate in the life of the community and to have sufficient resources to obtain a decent living. It is a minimal measure. For a country that has achieved a high value of the HDI, the question then arises about other dimensions in which people can grow" (UNDP 1993). Thus they explicitly tie measures of averaged national achievement to the goal of expanding individual opportunity.

Another important difference among these approaches is whether they measure, in economic terms, inputs or outputs. Phrased in standard English, the question is whether to measure well-being directly, as health status and happiness/SWB research surveys do, or to take the measure of assumed determinants of local, individual, or national well-being. At the conceptual level, both have their flaws, especially in the context of SD reporting.

Measuring inputs has the advantage of objectivity, and, especially for "official" reporting, this adds to public credibility. The drawback is that it is never clear that these various factors really matter to individual happiness, life satisfaction, or well-being. Indeed, from an SD perspective, the fascinating aspect of happiness research is how often its research studies call into question the things that we assume matter immensely. Most notably, although income and health certainly do matter, their relationship to happiness is complex, with issues of adjustment to change, envy, and social status (among others) clouding the picture (Myers 1992). Conversely, factors that are rarely considered in SD reporting, such as self-esteem, optimism, regular exercise, sociability and outgoingness, a sense of personal control, a strong spiritual base, and supportive social networks are extremely important.

On the other hand, measuring outputs (happiness, health, life satisfaction) directly by surveying individuals has its problems, too. There is always the question of how truthful and accurate people will be; but more significantly for SD reporting, such surveys can be costly (polls asking such questions are not uncommon, but this is not information routinely collected by government statistical agencies). And conceptually, the deep problem here is that, since so many factors influence outputs, outputs alone give us no information that could help inform public policy or private decisions. It is only when the relationship of various factors to the reported levels of health or well-being are clear that the information becomes meaningful.

Issues of Synthesis

The concluding questions in this paper's discussion of approaches to measuring human well-being as a dimension of SD reporting are: what happens to human well-being as approached in these various ways when put in the larger context of SD? And, what linkages with ecological health and human activities stand out as interesting or needing further examination?

This topic is really too large to examine in detail here; it deserves a review of its own. Nevertheless, I will make a few preliminary observations.

First of all, the robust relationship between economic factors and human well-being still stands in stark, problematic contrast to the assumption of many environmentalists that economic activity must be slowed, stopped, or reversed, at least in the developed world,

for ecological reasons. The only way to move forward on this impasse is to have a more accurate understanding of the ecological limits to human activities, and a better sense of the political, organizational, and technological changes that might be possible in order to adjust these activities both to income growth and environmental constraints.

Secondly, the happiness research suggests that the social dimensions of involvement in work, home, and community play a powerful role in contributing to well-being. Thus, while the actual activities that humans undertake interact directly with the physical environment and are important to report on because of their contribution to environmental change, it may be that the organizations and social structure by which collective activities are carried out are equally important for human well-being. I am thinking, for example, of the finding that personal control is vital for well-being, or that happy marriages and other social ties are critical, as well. Public and private policy related to fostering personal involvement and control, or that support families, may turn out to be as important for a nation's real well-being as its average income.

Finally – and this is not a serious conclusion – I feel bound to pass on one of the most intriguing small findings that I ran across. In his broad examination of happiness research, *The Pursuit of Happiness*, Myers (1992) notes that many studies link charitable giving, of both money and self, with happiness. Then he adds, in passing, that in one study, economics professors were more than twice as likely as those in other disciplines to contribute no money to private charity. And in laboratory monetary games, students behave more selfishly after taking economics courses. Even though I am in general an advocate of more, not less, economic theory and analysis in environmental matters, perhaps there is a lesson here: the traditional models of economics may not be the best perspectives on which to structure the human well-being dimension of SD reporting.

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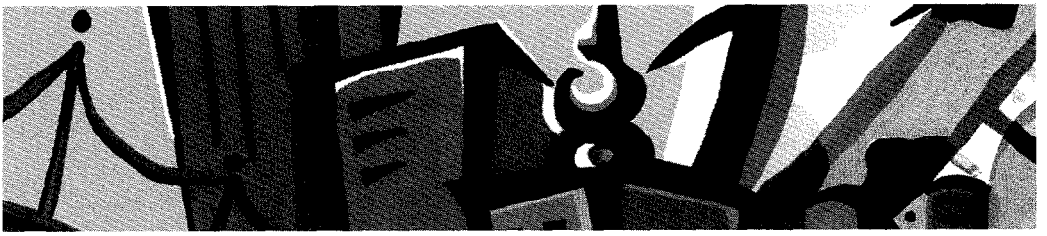


Proceedings

Approaches to Reporting on Human Well-Being

Presentation by Susan Holtz

It is important to remember that value judgments are built into the fabric of sustainable development reporting, and to be aware that values are especially pertinent when it comes to assessing human well-being. In fact, because values are so central, it may make cross-cultural comparisons difficult. When we try to deal with quality of life, for instance, we can be immediately thrown back into the age-old question that Aristotle wrestled with, namely, what is the good life? Answers to that question vary from group to group and from person to person.

It is also necessary to avoid the traditional approach of regarding human beings and the surrounding ecosystem as separate domains of information. In reality there is no separation. And even though there may be a nominal separation in the reporting of human well-being, deeper analysis reveals that many of the reporting systems reflect that the well-being of people cannot be disentangled, even conceptually, from their physical environment. Nor can their physical environment be disentangled from the social and economic environment. However, reading reference materials on human well-being – on methodologies and definitions and assessments and attempts at measurement – was very frustrating. It is a disciplinary morass.

Response

Synopsis of Response

The response to Ms. Holtz's paper took the form of a series of observations and questions that touched on issues such as the growing sense of insecurity people feel, whether limits to growth should be accepted, whether efforts should be made to limit consumption, the need for public participation, the changing social role of corporations, and how wants and needs relate to happiness and well-being.

However, there was no sustained exploration of any of the issues or ideas raised, and no attempt was made at consensus. Participants circled the idea of reporting on human well-being, but in the end could not find an entry point that enabled them effectively to grapple with it.

Critique

No formal critique of Ms. Holtz's paper was undertaken. One was scheduled, but the person who was to deliver it was unable to attend the colloquium at the last moment. Instead, the colloquium moved immediately to commentaries.

Commentary: Making Observations, Posing Questions

Many of the indicators currently in use, such as longevity, education, per capita income levels, and nutrition are crude and do not capture the notion of well-being. Even in situations where people are relatively well off, there are studies to show they are working longer hours to avoid falling farther behind or even losing their jobs.

The fact that people are working longer cannot be blamed on greed or some kind of consumer pathology. It seems that people are motivated more by a fear of losing income and they are not willing to leave the income level that they have. Nevertheless, they are prepared to look for more leisure in the future.

Look at the resistance in Ontario to the "social contract" wage cuts implemented by the provincial government. Or at the Nova Scotia government's efforts to trim costs. Income is a proxy for what people buy but it is also a proxy for what they feel they have lost. Loss of choice in a shrinking world can leave people feeling constrained far beyond the material losses they are actually experiencing. Much of the stimulus for this comes from a shift in rhetoric.

This distinction between perception and reality can be seen most readily when people cut back on income because they want to. For instance, when it comes to shrinking a lifestyle in order to send a child to university, they do so quite readily.

The issue of leisure versus higher incomes seems to pose an impasse and, as yet, we have not found a way to get past it. It appears to be based on high levels of insecurity.

The only way forward is to abandon limits-to-growth thinking, that is, the kind of thinking that declares as good all efforts to protect what we have, while branding as bad all aspects of consumerism. It is an old-time environmental approach. It has a puritanical ring to it and it simply adds to insecurity.

Not only does it add to insecurity, it turns people off. It is the imperialism of frameworks. If that line of thinking is carried forward it calls for massively restraining consumption in lesser developed countries – and there is a strong argument to be made that such a move, in itself, would be immoral.

We should be looking at the way in which Eastern societies, for centuries, have dealt with uncertainty. They have accepted it, instead of fighting it. However, Eastern societies were able to cope with uncertainty because of large family structures. We do not have large families any more.

The gross national product should really be called the gross national cost. It would help to underline the mania for growth that has gripped us in the post-World War II period. In terms of that kind of growth, it is not immoral to restrict consumption. Limits to growth should be recognized. It is a very serious issue. In an ideal world we all would like to increase consumption among those with little. But the prospect of doing so is small because of the pressures in all areas of the ecosystem. The medical realities of a system breaking down are not pleasant to observe. But in the global ecosystem, that is what we face.

There are real and significant differences between the North and the South. By comparison,

what we in the North require for happiness has much more to do with want than with need. If consumption were to be restricted in cases where it could meet needs, it clearly would be immoral.

There is no doubt that people feel constrained. Most are in debt. Most are in thrall to the dynamic of television, where all advertising and most of the programming is aimed at equating consumption and happiness. We cannot ignore this. Or, at least, we can ignore it at our peril. It trivializes the situation to try to distinguish between needs and wants. If something makes you happy, how can you say it is not a need? Nevertheless, "choice" is one of the key variables. In the reporting of indicators, the news will rarely be all bad. It should be related to needs and wants, but there should be a leavening of reality.

The National Forum on Family Security (which is sponsored by the Laidlaw Foundation) commissions policy papers and conducts seminars to stimulate discussion of issues bearing on family security in Canada. A recent publication, *Family Security in Insecure Times*, tried to identify the main focal points for any discussion of economic security. They were:

1. the adequacy of levels of living: at any given time a household needs an adequate level of income and access to public services to provide for its basic needs;
2. whether standards of living are assured: people need to know that an adequate level of income and public services can be maintained over time; and
3. poverty: the word speaks for itself; it represents the extreme of insecurity.

The publication found that a sense of insecurity is spreading and that in trying to deal with the causes, the political process is becoming paralyzed. It suggests that we need to think in terms of quantum shifts, not in terms of tinkering with the system; that we need to find a new balance between individual and collective responsibilities; and that the privatization of risk is neither beneficial nor morally acceptable.

In the 1960s, the assumption that consumption was good for the economy led to many absurdities. Now it is time to look at consumption from a different perspective. For instance, why should we continue to regard national income as a measure of national welfare? It does not measure welfare at all; it measures economic activity. In point of fact, the objective of economic policy should not be to achieve growth; it should be to conserve stock. If we measured income as flow from stock, the resulting figures would be very different.

A loss of options, for instance, a drop in income or a reduction in ecosystem services, creates a negative in terms of human happiness. Limits to growth, and all the restrictions that they imply, put a further limit on options and a further drain on happiness, at least under our current mindsets. Every time we turn around, all we see is options curtailed or threatened. No wonder we feel insecure. Is there no way of offering compensating options? Social options, perhaps? A very frugal life could also be a life very rich in social recognition.

It is the knowledge that there is something out there, Tweedsmuir Park at Bella Coola, for instance, and not whether we actually use it, that has a great deal to do with peace of mind. Perhaps we should be experimenting with interpretative polling in an effort to measure quality of life. However, at the moment, we do not know how.

At the same time, we do know that self-esteem is very closely linked to a sense

of well-being. People used to make jokes about a happiness index. But Tolstoy observed in *War and Peace* that happy families are almost all the same, while unhappy families are almost always different.

However, the question arises: are happy families happy all the time? What time frame do we talk about when we are speaking of well-being?

What about causality? Ms. Holtz was asked if she had been able to identify any patterns? Yes, she said, health was seen as having a direct effect on well-being.

Another speaker noted that in the early years of this century, people needed good health to get a job, mainly because so much work tended to be physical. Consequently, health was a good indicator of income. Now, however, not having a job is a good predictor of bad health. Because of AIDS, a lot of research is being done on immune systems. What it shows is that when people lose jobs, or experience other trauma, there is a direct and deleterious impact on their immune systems. And when they go back to work, there is an improvement in their immune systems. It is much easier for people to accept change, such as income loss, if the situation is the same for everyone.

In Latin American literature, community participation plays a large role. North Americans should be concentrating more on how to encourage it.

In so far as participation adds to control, it is important. But the forms of participation matter a great deal in determining whether people will get a sense of control. For example, during the last few rounds of constitutional debate, there was a fair amount of participation but no real sense of control.

Personal and collective activity are both important in achieving self-determination, independence, and security.

We need to ask ourselves many more questions about what is distinctive about communities. People's view of what is best for them can be quite different from what they think is best for their community.

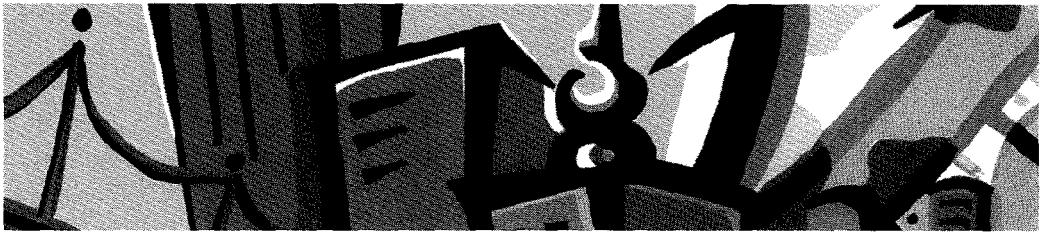
A Gallup survey found that poor countries were just as concerned about the environment as well-off countries. The only real difference was that developed countries worried more about the global environment, while lesser developed countries worried more about their local environments.

One topic that should be addressed [in the colloquium] is power, in particular, the power of the multinational corporation. Not everyone is coming from the same place. There are different power implications that flow from whether a person comes from an upper, middle, or lower income group. However, there is a much greater division where multinationals are concerned, and it relates to the issue of who can take action and who can influence decision making.

Corporations used to have a social purpose; they served as massive employers. But they no longer serve that purpose. In fact, led by multinationals, they now fire people at will and in masses. And they shift operations to other parts of the world whenever local conditions do not meet their particular requirements. As a result, they no longer should get the kind of public support that they are used to because they no longer serve the purpose they once did. We have been operating under a 300-year-old convention that exploitation is good. Sir Francis Drake was admired. The British Empire was built on efficient exploitation. However,

that convention now is destructive and we have to ask whether there is a structure that is more suited to the times. The Drake model has led corporations to focus narrowly on assets and their exploitative opportunities. It is important to remember that structures do shape people's attitudes, and corporate conventions and structures have promoted attitudes that are destructive. Perhaps we should be turning to a strict discipline for work, such as Mennonites practise.

A criterion for well-being that has never made it into the literature is aesthetics. Should it not be there? Do pretty, or pleasing, surroundings not have an impact on a sense of well-being?



Synthesis of Discussion

By Ted Schrecker, Associate Director (Environmental Ethics)
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The November 1993 colloquium on sustainable development reporting generated two days of intense and high-quality discussion. Providing a brief and useful synthesis of that discussion is, to put it mildly, a challenging task. I have chosen to organize this synthesis with reference to five key sets of questions or tensions that emerged in the course of the two days. The colloquium did not answer these questions or resolve these tensions.[1] It did, however, clarify them in a way that has seldom been done as effectively. In my view, further work on sustainable development reporting would benefit from explicit reference to these questions and tensions.

Question 1. What are the appropriate roles of science, scientific inquiry, and scientific concepts in sustainable development reporting?

The colloquium opened with a presentation organized around the concept of ecosystem health as a transdisciplinary conceptual framework that goes beyond a particular aspect or characteristic of an ecosystem, and one that is broader than sustainable development. The analogy with the health of individual organisms (such as human beings) is provocative, since it suggests the importance of the results of scientific inquiry yet situates those results within an integrative conceptual framework that also involves judgments and normative commitments. To continue the analogy, equating human health with the absence of impairment in the functioning of particular organ systems would today be rejected by many health scientists and practitioners, who opt instead for a more holistic vision.

In contrast, another participant argued that ecosystem health may be a narrower concept than sustainable development, and that there are limits to the health analogy: "What's wrong with accepted terms such as ecosystem sustainability, and why do we think we have to borrow terms from another field to validate our concepts?" More than one participant warned against "conceptual imperialism": the tendency of many people to use the concepts associated with their own academic or professional disciplines. The basic issue is deeper than this, however. We may want

to ask whether a particular practice is ecologically sustainable, whether a particular ecosystem is healthy, or any number of possible formulations. In each of these situations, the question simply cannot be answered with the same level of precision as the question of whether a particular heavier-than-air craft will fly or whether a particular compound will explode under specified laboratory conditions.

Even participants who were sceptical about the value of the concept of ecosystem health appeared to accept the claim that there is an inescapably normative dimension to the choice of indicators, criteria, and data sets. One participant stated the issue in terms of having to decide what we must conserve in order that we can consume. Another extended the argument, saying that beyond deciding what we must conserve, the issue is what we *want* to conserve: landscapes and ecosystems are in a continuous state of change, quite apart from the effects of human activity. Still a third identified a key distinction between facts (e.g., there is a Second Law of Thermodynamics) and interpretations (e.g., human activity worldwide, or in a particular region, has exceeded the carrying capacity of the relevant ecosystem). The executive summary of the report of Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC) was cited as a laudable example of how attention could be drawn to such distinctions in practice.[2]

A number of important points emerge from this set of concerns. One is the need for decision makers, be they individual consumers, private sector managers or politicians to acknowledge that decisions related to sustainability must be made, and are being made every day, in a context of pervasive uncertainty. This uncertainty may be a consequence of incomplete data; at least as often, however, it is a consequence of incomplete conceptual understanding of how ecosystems operate. For example, the response of ecosystems to particular stresses or combinations of stresses may be non-linear; we cannot yet predict the point or threshold at which response patterns change from linear to non-linear. A closely related point is that of the probabilistic nature of scientific and policy conclusions: how much certainty is needed, or can be obtained, about such key questions?

Participants occasionally stressed the continuing need for basic data and information, and the value of those data that have been or are currently being gathered. A disagreement that remained largely implicit has to do with what can be inferred from those data. The need was identified for "a suite of indicators" that would, taken together, tell users (1) the ecosystem's prognosis, and (2) the significant trends. In other words, are the relevant indicators headed in the right direction? Leaving aside for the moment the value choices associated with the implementation of any such recommendation, discussed at greater length under questions 4 and 5 below, one of the implications is that indicators must be related to a process of change, rather than simply providing a snapshot of the current state of the ecosystem in question. (One participant warned that "we are still dealing in taxonomies" of impacts, and that more attention to dynamic rather than static indicators is needed.) Another implication is the need to identify signals or early warnings that more fundamental changes are occurring. Although the example was not used during the discussion, the set of leading economic indicators used in Canada and the United States may be useful by way of analogy.

How easy or difficult will it be to generate indicators that can meet such demanding tests, given the present and reasonably anticipated state of knowledge about how ecosystems

behave and respond to stresses both exogenous and endogenous? Leading economic indicators, after all, are generated based on a wealth of data about a system whose operation is presumably rather well understood, at least at the macro level and in statistical terms. It may be that given continued research and reporting efforts, such a suite of indicators will in time emerge. (This could be characterized unkindly as the *Field of Dreams* principle.) On the other hand, are the ways research is conducted and data are gathered adapted to the requirements of decision making under conditions of uncertainty or incomplete information, and to a broader perspective that emphasizes holism, as in the approach of public health specialists and ecologists, rather than reductionism?

Question 2. How, if at all, can the tension between simplicity/practicality and comprehensiveness in sustainable development reporting be resolved?

Question 3. Who chooses the indicators or values of greatest importance, who should choose, and how do we best ensure that the indicators are useful?

It can be argued the more indicators there are, and the more they are subject to interpretation, the less usable they will be. "Keep it simple" and "get practical" were exhortations delivered, in one way or another, by several colloquium participants. One argued for "a small set of indicators that are easily understood to increase people's awareness of their individual and collective actions." At the same time, another participant was "exasperated by the fact that people continue to try to expand an indicator beyond its normal definition and magically make it predict events or conditions." Ideally, it should be possible to select *and* test a limited number of key indicators or "linchpin variables" in terms of their ability to predict significant changes in the ecosystem features that are of greatest concern. Is the available understanding of ecosystem functioning, in practice, comprehensive enough to make such a selection possible? (One participant noted that data needs may be simplified as that understanding progresses.) How complete an understanding is really needed or do we already know quite enough about the nature and source of stresses on ecosystems to know what to avoid? (Another participant suggested that the policy imperative of reducing stress imposed on the ecosystem be taken as given.)

The analogy with economic indicators may be useful here, as well. The U.S. index of leading indicators is a single number reflecting the performance of 11 indicators, each of which is assigned a particular weight.[3] Changes in the index may be reasonably reliable as predictors of the future performance of the national economy, in the absence of substantial exogenous surprises such as natural disasters, oil embargoes, and drastic changes in the policies of major foreign governments. However, the acknowledgement of complexity is sacrificed in order to achieve simplicity and quotability; so is the ability to make micro-level predictions about the performance of particular industries, firms or regions, for which different and considerably more specialized information is needed. Finally, the choice of weighting for the index presumes widespread agreement both about the importance of particular indicators with respect to national economic performance *and about the proper definition of economic performance itself.*

In practice, such questions in the choice and design of indicators are likely to be unresolvable without reference to who will use the indicators, and for what purpose. Different

decision makers clearly will want and need different kinds of indicators. The key question therefore becomes that of how to determine which particular indicators are most useful for any given set of decision makers, whether households, firms, or governments. One participant pointed out that the insurance industry has developed a high degree of sophistication in selecting ecosystem-related indicators of its own financial risk; ocean temperature levels, for instance, are used as an indicator of the probable frequency of hurricanes. This is an example of how sustainable development can be, and has been, "sold" to the financial services industry. In response, another participant pointed out a key difference between this situation and the one in which indicators of sustainability are usually developed. A feedback mechanism clearly links an insurance firm's choice of indicators with its subsequent success or failure, as defined in the marketplace: if the insurer's understanding of the relevant systems or its information base is incomplete, it will suffer serious and potentially fatal financial losses.

In theory, as one participant pointed out, sustainable development reporting should itself serve as a feedback mechanism for decision makers. The problem is that no feedback mechanism comparable to those operating in the insurance industry exist with respect to governments, which are motivated primarily by the desire to retain or consolidate power and do not usually do this or fail to do this based on how well they select indicators of sustainability. Indeed, when the indicators are publicized to a broad audience rather than restricted to internal use, governments and firms may have a vested interest in choosing indicators and designing reporting procedures that will accentuate the positive: "look how well we're doing!" This has an uplifting effect in terms of public attitudes, but deflects criticism of those institutions' performance. A useful analogy is to accounting procedures that paint the rosiest possible picture for shareholders. Accountants have agreed on professional conventions and standards that limit the opportunities for deception in this context; are there, or should there be, similar mechanisms ensuring the accountability of those doing sustainable development reporting? One participant suggested the need for "reporting on" the performance of institutions, as well as (and in contrast to) "reporting to" them, and for "an arm's-length, credible relationship" between those being reported on and those doing the reporting. Another argued that accountability could be enhanced by way of a debate among key decision makers from both public and private sectors in which they would explain why particular environmentally relevant decisions have been made in four or five key situations.

A problem not fully addressed during the colloquium is that of whether, in a system of sustainable development reporting that is organized around the needs of particular categories of users, some categories of information will fall between the cracks, yet be crucially important in assessing the nature and direction of changes within an ecosystem. The issue is partly one of scale, since no institution may operate at a scale that corresponds to the relevant ecosystem. Watersheds managed according to priorities that differ and sometimes conflict depending on which of the many relevant jurisdictions is involved are a familiar case in point; the Great Lakes Water Quality Agreement was cited as an effort to overcome this problem, at least in terms of developing reporting systems. Impacts on local landscapes or the regional availability of ecological services may result from investment or policy decisions made in Tokyo, London, or New York based

on priorities having nothing to do with the values of the people affected by those impacts. Conversely, the choices of individual consumers and local governments may contribute to global impacts, as in the case of consumption and land-use planning decisions that favour short-trip auto travel.

For all these reasons, there may be a need to pay special attention to aspects of the human-ecosystem interface that are treated as everybody's business, and therefore nobody's, by the institutional actors whose decisions affect them. Are there things about the sustainability of present patterns of human activity that the relevant decision makers *ought* to know, indeed that should be brought persistently to their attention?

Question 4. How do human beings and human welfare fit into the sustainability equation? What is the role of economics?

As a starting point for further discussion, the description and reporting of human well-being was reviewed with reference to six approaches: economics, specifically the measurement of income and wealth; health; quality of life; politically selected benchmarks or targets; indicators of human development; and happiness or subjective well-being.

There is, in fact, a multiplicity of statistics and indicators related to human welfare, yet one participant noted that human well-being is the aspect of sustainable development that has been dealt with least adequately for reporting purposes. In the Canadian context, the spread and deepening of insecurity at the family level was cited as an indicator of deterioration in human well-being. This insecurity has to do not only with current income levels, but also with uncertainty about future income levels as unemployment stays high and the risk of unemployment touches more families. "People are working harder to keep their jobs, not to have more money," said one participant. Although the point was not made explicitly, the use of family security as an indicator of human well-being suggests a weakness in many of the conventional indicators of human welfare, including not only national income per capita but also health and educational status indicators of the kind used in the United Nations *Human Development Report.* In such global league tables Canada continues to rank near the top. Is family security perhaps a superior indicator in that it captures incipient changes in the level of human well-being that our social system is providing, while avoiding the pitfalls of aggregation?

Gross national product and its variants are perhaps the most familiar aggregates of all, yet it was noted repeatedly that national income figures do not provide an accurate measure of human welfare. Indeed one participant quoted with approval Kenneth Boulding's redefinition of GNP as gross national cost. On the other hand, the importance was pointed out of acknowledging the North/South economic difference; whereas human well-being for many people in the North is defined principally in terms of satisfaction of wants, for many in the South the issue is one of seeking the satisfaction of basic needs, whether or not the possibility of satisfying those needs is directly correlated with national income levels. There are possibilities, said some participants, both for adopting a richer cultural life in conjunction with a more frugal material life, avoiding what one person called "stupid consumption," and for "decoupling" economic growth, measured in conventional terms, from the material and energy throughputs that are the source of concern in terms of ecological impacts. Relatedly, want satisfaction often tends to be related to "positional goods," which by definition can be enjoyed only by a limited number of people or

households; a consumption spiral is thereby effectively built into the economic system. However, scepticism was also expressed about the want/need distinction, which at least one participant found problematic. The practical question here is that of whether, and if so how, reliable distinctions between want satisfaction and need satisfaction can be developed for purposes of reporting on human well-being.

What role should the discipline and the conceptual lenses of economics play in sustainable development reporting? This question is particularly important in the context of modifying systems of national accounts (SNAs) to take into account the costs of ecological damage and resource depletion. Some participants expressed considerable scepticism about the concept of weak sustainability, which implicitly presumes the feasibility of high levels of substitution for resources ("natural capital") and ecological services. One participant commented that a necessary precondition for all economic activity is *some* continued provision of ecological services, and in any context it is the resource or service that is in most limited supply that provides the limiting constraint on economic activity. It was also pointed out that SNAs were originally designed to provide certain quite specific and limited kinds of information, and should not be stretched to fit information needs of quite a different kind; instead, a plea was made for "pluralism" in SNAs.

On the other hand, there were some expressions of approval for the efforts made by researchers under the auspices of the United Nations Statistical Commission (UNSTAT) to assess the impact of current resource management and environmental practices on a national economy's future income-generating abilities. "Money is part of our information feedback system," in the words of one participant; "it helps us keep track of entitlements and obligations." Another suggested at least an indirect link between economic growth and human well-being, noting that cutbacks in the availability of Canadian health services, as the recession shrinks government revenues, are having an impact on health and quality of life that was substantial yet (once again) too subtle to be captured by existing indicators.

Conceptually, the question is whether national income may in this respect be an imperfect yet worthwhile proxy for human welfare. Practically, the question is how to develop or modify existing indicators so that they reflect such subtleties as deteriorating health service availability or increasing levels of family insecurity. Alternatively, if one defines the sustainability imperative in genuinely global terms "we" may be sufficiently well off that such subtleties are largely irrelevant. However, the problems associated with this approach were identified by participants who cautioned against the moralism, "Puritanism," or "holier-than-thou attitude" implicit in the stance of some environmentalists toward economic growth, which implies a relative indifference toward the implications of limits-to-growth in terms of the ability of an economic and social system to satisfy wants and needs.

Question 5. Is there an underlying vision of sustainability that everyone involved in the policy discourse shares? If so, what is it? If not, can genuine pluralism in problem definitions and solutions be accommodated?

This question recurred throughout the discussion in various forms. It is partly related to "conceptual imperialism," and to the tendency of specialists to talk the language of their own kind. At the same time, the preceding reference to the limits-to-growth debate suggests more fundamental tensions. The conceptual value

of ecosystem health as an integrating framework, for example, was defended by one participant with reference to a "dire warning to humanity" about the consequences of ecological breakdown, reflecting the consensus of a large number of scientists; the "realities" associated with the health analogy "may not be very pleasant," but must be faced along with the implied limits to certain dimensions of economic growth. Other participants made similar points in language that stressed the "urgency" of paying attention to sustainability, resisted the implied immorality of assertions about limits to growth, or challenged the relevance of reporting systems organized around a principle of weak sustainability.

These tensions occurred within a gathering of people remarkably homogeneous not only in socioeconomic terms, but also in their occupational or professional involvement with institutions that are organizationally committed to sustainability in one way or another. It is not clear how representative they were (or, for that matter, should have been) of the spectrum of Canadian values on this point. If sustainable development reporting systems are to convey information that will be of value and interest to people outside a fairly narrow circle of specialists, they will have to meet the formidable test of achieving simplicity *without* sacrificing either transparency or amenability to conflicting interpretations. What this rather cryptic formulation means is that when item of information A is presented as indicating changes B_1–B_n in the state of a particular ecosystem or its ability to provide services, the links between the indicator and each of the relevant changes will have to be explicable with conviction, and with explicit acknowledgement of the uncertainties involved. What does a decline in the numbers of a particular species of predator, or in urban residential population density, really mean? How certain is the connection? Along the lines of the IPCC Working Group report, information provided should always be transparent, and should admit of conflicting interpretations. This test becomes more critical as large volumes of information are distilled or condensed into indicators, in the interests of simplicity and comprehensibility. It is also likely to become more critical as sustainable development reporting moves beyond reporting on characteristics of biological systems, and on the sources of human impacts on those systems, into the area of human well-being.

As difficult as all this sounds, it is only the first of three tests for a comprehensive system of sustainable development reporting. The second test is that of providing information that will enable people outside the narrow circle of specialists to decide whether, why, and how much it all matters. This is particularly important if sustainable development reporting systems are to provide the basis for integrating the various information domains identified by the National Round Table's task force. Who should care about predator species, or urban population densities, and why? How, if at all, does the information provided affect their particular objectives, or those of the institutions that determine how they spend their working hours? Once explained, this point appears obvious with respect to the insurance industry's interest in ocean temperatures. There are situations where explanation will render the connections similarly obvious. In other situations, the connections may simply not be there. Not everyone, and not every institution, functions within an incentive structure that is hospitable to considerations of sustainability, almost regardless of how one defines the term.

This observation suggests a third and final test, the educational one of providing information useful for making connections between outcomes and incentives structures. Most decision makers in any context respond to particular sets of incentive structures, of which price is perhaps the most familiar. In many cases they also contribute to the incentive structures relevant to other decision makers. Governments decide how their revenue requirements are to be met, choosing (at least in theory) among an infinite number of hypothetical tax systems. Firms set prices, responding to market pressures but also using (or refusing to use) revenues from one product or service line to cross-subsidize another. Households decide to keep the old car for another year, even though it gets mediocre fuel mileage, thereby in an admittedly minuscule way altering the incentive structures relevant to car makers, oil companies, and governments as well as responding to the incentive structures created by previous institutional decisions that affect household incomes. The connections are often hard to establish clearly. Sustainable development reporting systems need not actually establish these linkages, but they should be organized with a view to providing information that will help in doing so.

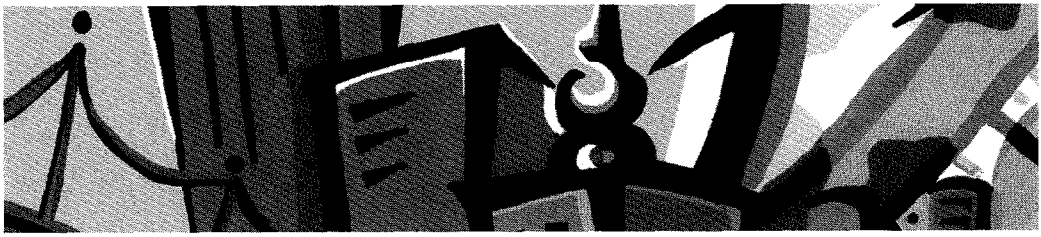
It would seem that reporting systems cannot resolve basic social conflicts about priorities, or about how the gains and losses from public policy and private decisions ought to be apportioned; they cannot reflect a consensus that does not exist. Some will be uncomfortable with this conclusion; early in the colloquium one participant commented that most decision makers cannot handle pluralistic value systems. However, perhaps reporting systems can improve that capability, by improving the quality and clarity of discussion about basic choices for the future, at every level from the kitchen table to the boardroom or Cabinet table.

Endnotes

1. Any one observer's view of what emerged from a meeting like the November colloquium is necessarily incomplete, even when informed, as mine has been, by the notes and subsequent observations of several colloquium participants. For that reason, the comments of other participants are more than welcome.

2. The summary ranks the panel's conclusions in sets depending on the degree of certainty attached to them by the panel. "We are certain of the following" is followed by: "we calculate with confidence that"; "based on current model results, we predict"; "there are many uncertainties in our predictions . . . due to our in complete understanding of certain factors"; and "our judgment is that..." Finally, ways are identified in which predictive capabilities related to climate change could be improved. IPCC, *Climate Change: The Scientific Assessment* (Cambridge: Cambridge University Press, 1990), xi-xii.

3. These indicators are: average workweek of production workers in manufacturing; average initial weekly claims for unemployment insurance; new orders for consumer goods and materials; speed with which companies receive deliveries from suppliers; contracts and orders for new plant and equipment; new building permits; change in manufacturers' unfilled orders for durable goods; change in prices for so-called sensitive materials; stock prices; change in the money supply; change in consumer expectations, as measured by standard surveys. In the case of unemployment claims, a decline is considered as upward movement. Source: *New York Times*, December 30, 1993, A1 and C15.



Appendix

Colloquium on Sustainable Development Reporting

November 25-26, 1993

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Part III

From Theory to Practice: Assessing Progress toward Sustainable Development in the Great Lakes Basin

By Tony Hodge, Chair
Task Force on Sustainable Development Reporting
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This case study is based on a section of R.A. (Tony) Hodge's doctoral dissertation: "Assessing Progress toward Sustainability: Development of a Systematic Framework and Reporting Structure" School of Urban Planning, Faculty of Engineering, McGill University, Montreal, 1995.

1. Case Study Boundaries and Problem Definition

1.1 Introduction

The purpose of this case study is to demonstrate a practical application of the systematic approach to assessing progress toward sustainability described in the National Round Table on the Environment and the Economy's report to the Prime Minister (NRTEE 1993) and developed in Hodge (1995). That system identifies four decision-making groups – individuals and households; communities; corporations and corporate groupings; and regional, province/state, or federal governments – and emphasizes the need to recognize their different needs and aspirations. This case study adopts a regional perspective with a primary focus on the Great Lakes basin ecosystem. It thus addresses the needs of regional decision makers and does not attempt to deal with the other decision-making groups.

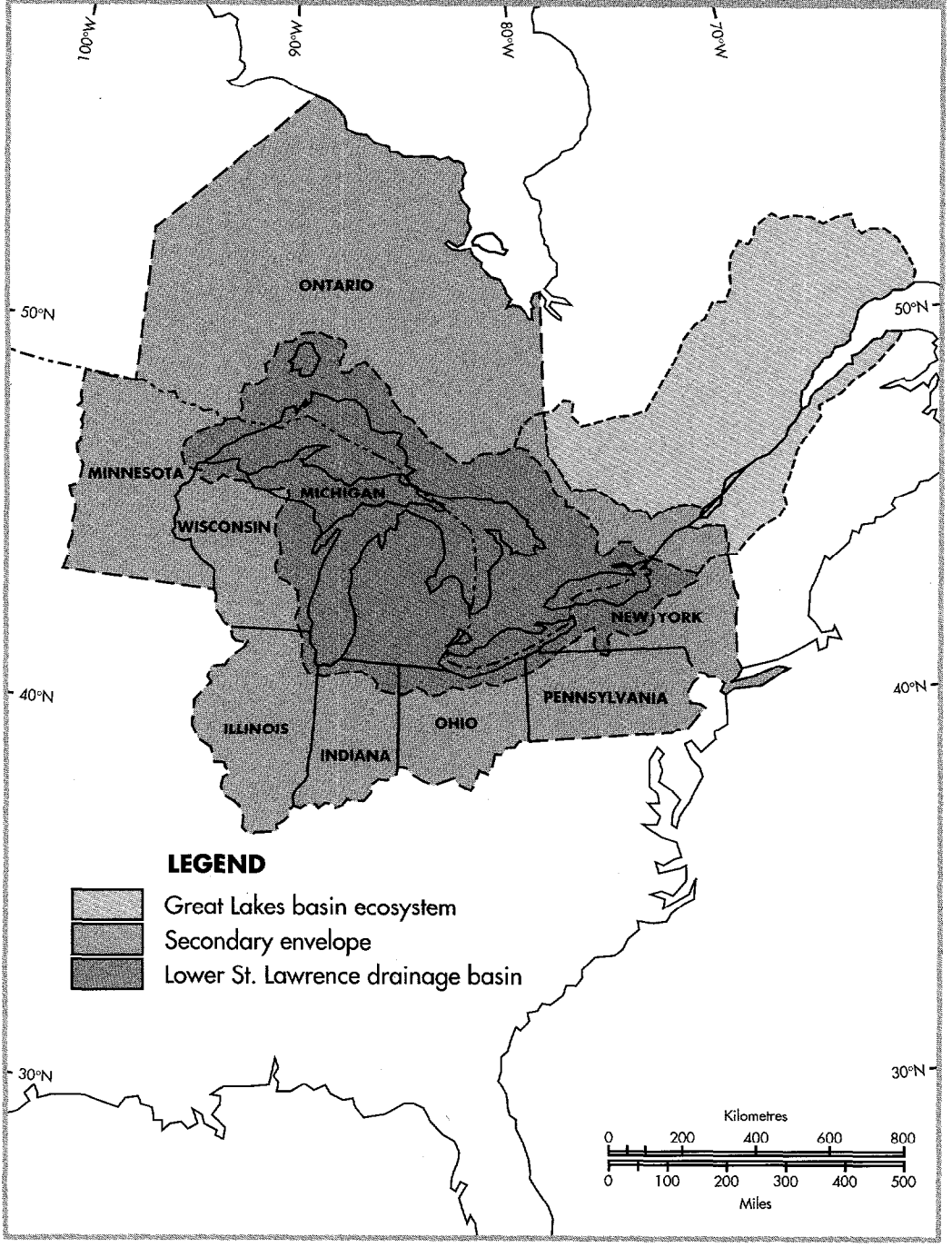
1.2 Boundaries of the Great Lakes Basin Ecosystem

The Great Lakes basin ecosystem serves as a primary focus for this assessment of sustainability. It is defined in the 1978 Great Lakes Water Quality Agreement as:

> *. . . the interacting components of the air, land, water and living organisms, including humans, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States. (IJC 1988, 4)*

It is an area shared by eight Great Lakes states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) as well as the Province of Ontario. Because the eight U.S. states and Ontario make decisions within the context of their entire jurisdictions, there is a second, broader political boundary. Figure 1 shows the Great Lakes basin ecosystem and the secondary state/province decision-making envelope. Also shown is the lower St. Lawrence drainage basin that would be included in the ecosystem along with Quebec, Vermont, New Hampshire, and Maine if the entire St. Lawrence drainage basin were to be considered.

Figure 1
The Great Lakes basin ecosystem and the state/province decision-making envelope



These boundaries, while providing a needed context for undertaking an assessment, are porous. The bounded areas are profoundly linked with the "outside world." Transboundary movement of water, air, energy, fish, wildlife, people, and their products (including waste) is constant.

Figure 2 provides a graphic illustration of the importance of this interconnectedness. It shows the "atmospheric regions of influence (AROI)" felt by the Great Lakes basin ecosystem. These regions illustrate how distant air emission sources can influence Great Lakes basin ecosystem conditions through long-range transport of airborne pollutants (LRTAP). The figure is derived from a 10-year database of air movement measured at six-hour intervals (Summers 1990, personal communication).

The potential impact of a given pollutant source depends on its location within the AROI and the resident time or "life" in the atmosphere of the emitted contaminant. For example, PCBs have an initial particulate life of 5 to 10 days (they can deposit in water and then revolatize to continue their global journey), whereas nitric acid and sulphur dioxide have a particulate life of about one day (Summers 1990, personal communication).

1.3 Setting the Stage for Assessing Progress toward Sustainability

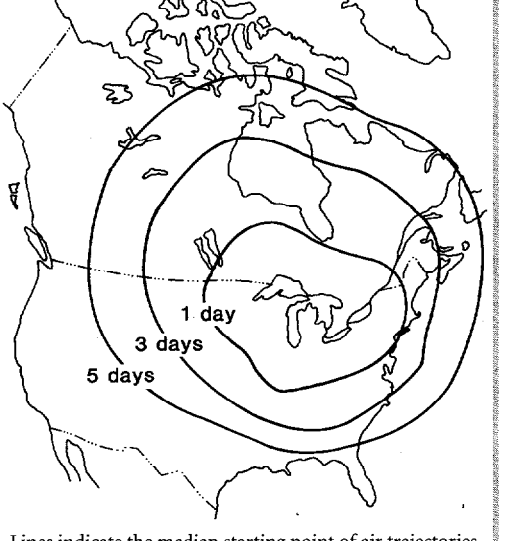
Seven building blocks must be addressed that together facilitate development of the proposed reporting system.

1. Definitions: Sustainability and Sustainable Development

Sustainability is defined as the persistence over an apparently indefinite future of certain necessary and desired characteristics of both the ecosystem and the human subsystem within (modified from Robinson et al. 1990). It is a normative concept. Thus the choice and the degree to which specific characteristics are to be sustained will depend on the operating set of values.

The sustainability of development (sustainable development) is the anthropocentric subcomponent. Development is used in the sense of realizing the potentialities of, to bring to a better state (Daly 1989, 4). It has both qualitative and quantitative characteristics and is to be differentiated from growth that applies to a quantitative

Figure 2
One-, three-, and five-day atmospheric regions of influence for the Great Lakes



Lines indicate the median starting point of air trajectories one, three, and five days prior to arrival at the lakes. For example, the three-day line indicates that half of the time the air in the basin would have originated three days earlier within that line and half the time beyond it.

Source: Summers and Young 1987.

increase in the physical dimensions of the subject.

Strictly speaking, it would be possible to differentiate a system of reporting on sustainable development from a system of reporting on sustainability. However, because people are part of the ecosystem, it makes little sense to do so.

2. *Value Base*

The value base underlying the proposed system of reporting is best described as a parallel concern and respect for the ecosystem and the people within – not one or the other, not one more than the other, but both together.

3. *Conceptual Framework*

Components of the systemic conceptual framework include the enveloping ecosystem, the human subsystem, the interaction between people and the ecosystem, and the related human decision-making processes. This framework emerges from (1) the underlying values; (2) examination of a range of theoretical treatments of the human-ecosystem relationship from economics, ecology, natural resource use, health, geography, planning, and, more recently, sustainable development literature; and (3) application of formal systems theory to untangling the resulting maze (Hodge 1995).

4. *Strategic Elements*

Four strategic elements emerge from the conceptual framework that serve as areas of diagnosis or "indicator domains" in the reporting system. They are:

I. **Ecosystem**: Data and information facilitating an assessment of the integrity and health of the ecosystem.

II. **Interaction:** Data and information facilitating an assessment of the interaction between people and the ecosystem: how and to what extent human activities contribute to the provision of basic needs and the quality of life; how these activities are valued; how these activities stress or contribute to restoring the ecosystem; and how successful we have been at meeting the goals and objectives of policies, regulations, and legislation.

III. **People:** Data and information facilitating an assessment of the well-being of people, including the range of physical, social, cultural, and economic attributes.

IV. **Synthesis:** Data and information facilitating the recognition of emergency system properties and providing an integrated perspective for decision making and anticipatory analysis that spans domains I, II, and III.

Each domain spans a complex set of data and information. Together they provide a template to be applied in support of different decision-making groups in society (individuals, communities, corporations, regions, provinces/states, nations, other decision-making groups). These strategic elements work because:

- in concept they are simple and understandable;
- they reflect the system we are dealing with;
- they keep the focus where it needs to be – on people and the ecosystem;
- they reflect traditional areas of knowledge that can usefully be brought to bear;
- they link to the current organization of government; and
- they allow an amount of "compartmentalizing" that is useful for strategic thinking but only within the concept of the whole system.

5. *Value-Driven System Design Criteria*

Guided by the first four building blocks, a number of value-driven characteristics can be identified that serve as design criteria for the reporting system. Thus the design of the system is guided by the following criteria:

- respect and concern for the ecosystem. This is achieved by:
  - using a time horizon in the reporting system that captures both human (short) and ecosystem (short- and long-term) time scales;
  - adopting a spatial frame of reference for assessing actions and decisions that extends beyond political and other boundaries to encompass the full extent of affected ecosystems; and
  - analysing individual ecosystem components (e.g., air, groundwater, surface water, soil, fauna, and flora) within the context of the connected ecosystem.
- the interaction between people and the ecosystem. This is achieved by:
  - being sensitive to the complete range of chemical, physical and biological stress on the ecosystem – including that occurring naturally and that imposed by human activities;
  - adopting an anticipatory perspective when determining how indicators, time horizons and analyses should be expressed, so that in the reporting process there will be a forward-looking thrust instead of just a description of past and current conditions; and
  - recognizing and accepting uncertainty as inevitable rather than an impediment to good decision making.
- respect and concern for people. This is achieved by:
  - using assessment criteria that respect the existence of alternative and changing values when evaluating progress;
  - assessing the distribution of environmental, economic, social, and cultural costs and benefits by examining their impacts on different social groups;
  - including ways to measure participation and control in decision making; and
  - using quantitative and qualitative measures that draw on both objective and subjective information, such as intuitive understanding based on experience of everyday life, including experience gained from subsistence and traditional lifestyles.

6. *Goals for Achieving Progress toward Sustainability*

In practical application, the assessment of progress toward sustainability must begin with the definition of general goals that provide a framework for subsequent identification of specific measurable objectives. The overall goal is to maintain or increase the well-being of people and the ecosystems of which people are a part. The following goals emerge when this overall goal is translated to apply to the four essential domains of data and information:

Domain I Goal

- to maintain or improve ecosystem health and integrity;

Domain II Goals

- to reduce the physical, chemical, and biological stress imposed on the ecosystem by human activities;
- to increase the extent to which human activities restore ecosystem health and integrity;
- to increase the ability of human activities to support human well-being;

Domain III Goal

- to maintain or improve human well-being; and

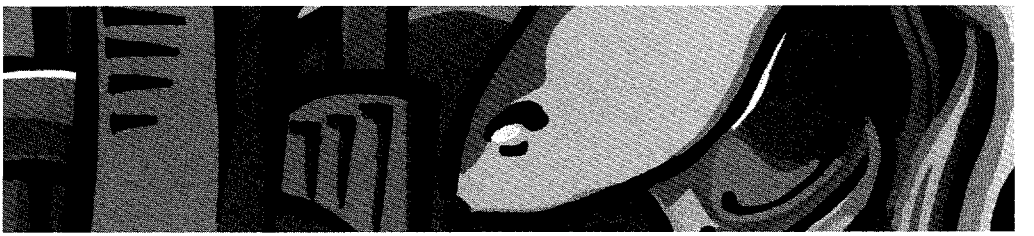
Domain IV Goal (Overall)

- to maintain or improve human and ecosystem well-being.

7. Purposes of the Proposed Reporting System

Lastly, the purposes of the proposed reporting system must be articulated. The overall purpose is to improve the way we make decisions: to support informed and responsible decision making and decision-making processes. Specific objectives include:

- to communicate key signals to targeted decision makers, in particular to give early-warning signals for required policy, institutional, and/or behavioural change;
- to ensure accountability;
- to encourage initiative by giving credit where credit is due;
- to identify knowledge gaps and provide rationales for giving priority to filling these gaps; and
- to provide a systematic framework for designing and staffing research in support of assessing progress toward sustainability and, ultimately, for determining the organization and content of the final assessment report.



2. Historical Context: The Great Lakes Story

2.1 Early Settlement

In the almost four centuries since Étienne Brûlé reached Georgian Bay, an explosion of human activity has vastly altered the region. From the beginning it was the region's inexpensive exploitation of abundant natural resources that provided the motivation for development.

Throughout the 1800s, vast tracts of forest in the Great Lakes region were stripped to clear land for agriculture. This deforestation, along with subsequent activities, provided the first massive set of imposed stresses on the Great Lakes basin ecosystem.

To power the grist mills that were needed to grind wheat and other grains, the settlers constructed dams along the thousands of streams and rivers flowing into the Great Lakes. The dams, in turn, changed the character of the water flowing to the lakes. Direct sunlight on the impounded water increased its temperature, and the dams blocked the migration of river-spawning fish (Weller 1990, 41).

In time, wood products were sought for markets not only in the United States and Canada, but also in Europe. Creeks and rivers were further dammed to provide energy for milling operations, while spring logging drives added to the damage of river ecosystems.

The result was large-scale and irreversible ecological change. By the mid-1800s, in addition to the vast deforestation, the eastern subspecies of elk and the passenger pigeon had been slaughtered to extinction and a large number of other wildlife species had been drastically reduced, including the timber wolf, wolverine, fisher, marten, otter, beaver, and wild turkey (Weller 1990, 39-40). At the time, these changes were accepted as a matter of course.

2.2 Transportation

The combination of an in-place water transport infrastructure and a strong natural resource base, including ready supplies of energy, promoted population settlement, agricultural development, and subsequent industrial development.

Today, because of its central importance to human activity in the Great Lakes region, monitoring the nature and state of the complex

intermodal transportation system is an important aspect of assessing sustainability. No comprehensive assessment of the transportation system has been completed. However, a number of indicators have been compiled that give cause for concern. For example, Thorp and Ballert point out that fully one third of the bridges in the eight Great Lakes states are now considered deficient (1991). This conclusion is consistent with assessments of the Canadian roadway system that have been completed for the Council of Ministers Responsible for Transportation and Highway Safety. Surveys commissioned by this council conclude that:

- 33 percent of the national highway system in Canada is below minimum geometric design standard;
- 18 percent of the system has serviceability deficiencies (i.e., it could not support an operating speed of 90 kilometres per hour under normal conditions or is below the appropriate local standard); and
- 26 percent of the system falls below the minimum standard for pavement strength and quality (Fields and Ruitenbeek 1992, 11).

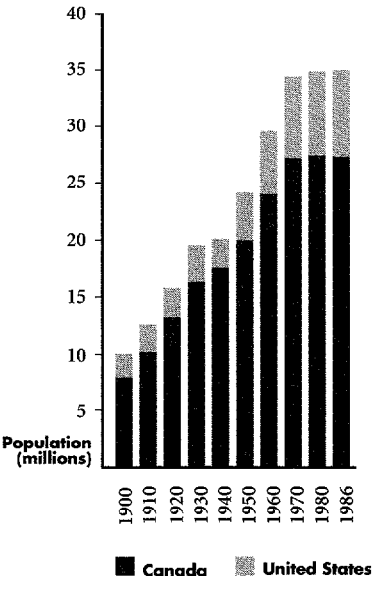
The Roads and Transportation Association of Canada articulates similar concern, arguing that "current spending levels are almost $2 billion annually under what they need to be just to maintain existing service and surface condition levels at what they were in 1978 – without allowing for further growth" (RTAC 1990).

2.3 Energy

The evolution of the Great Lakes system of energy production and use stands shoulder to shoulder with development of the transportation system as a contributing factor to the nature and pace of change. Early settlers found a ready supply of wood for direct burning or manufacture of charcoal. With settlement, the use of hydraulic power for grist mills, saw mills, and other factories quickly took hold. However, it was the harnessing of hydraulic power for electricity generation that contributed to the quantum leap in industrial activity in the Great Lakes basin that occurred early in the 20th century.

By 1896, an alternating current hydroelectric system was in place and a transmission line from Niagara Falls to Buffalo was formally in operation. Buffalo was the first city in the world to be illuminated by alternating current (Braider 1972; Goldman 1983). Coal, oil, gas, and nuclear sources now contribute to the energy regime in the Great Lakes basin ecosystem.

Figure 3
Population in the Great Lakes basin 1900-1986



Estimates for the United States are on the even year of the decade (1900, 1910, etc.); Canadian estimates are for the first year of a decade (1901, 1911, etc.).

Source: Colborn et al. 1990, 56.

2.4 Manufacturing

The dawning of the age of hydro-electric power brought profound change. Inexpensive hydro-power provided the underpinning of an iron and steel industry that drew ore from Lake Superior and coal from Pennsylvania. The chemicals industry emerged with its similar need for both energy and a transportation system to deliver the needed feedstocks and to distribute the resulting products.

This phase of economic development brought the second wave of imposed stress and resulted in massive ecological change. In contrast to the dominantly physical stresses imposed by deforestation, land clearing, and water-course modification of the first phase, this set of activities generated chemical stresses whose full significance is only now emerging. Municipal and industrial waste products spewed into the air, rivers, and lakes or were buried in the mistaken belief that the subsurface provided safe and stable storage.

2.5 Population and Settlement Trends

During the past four centuries, the human population of the Great Lakes basin proper has grown from a few hundred thousand to over 35 million. In-basin population trends for the period 1900-1986 are shown in Figure 3. Figures for 1970-71, 1980-81, and 1990-91 for the eight Great Lakes states and Ontario are listed in Table 1.

Table 1
Population in the eight Great Lakes states, Ontario, Canada, and the United States

	Population (thousands)		
State/province	**1970/71**	**1980/81**	**1991**
Minnesota	3,806	4,076	4,432
Wisconsin	4,418	4,706	4,956
Indiana	5,195	5,490	5,610
Ontario	7,703	8,625	10,085
Michigan	8,882	9,262	9,380
Ohio	10,657	10,798	10,941
Illinois	11,110	11,427	11,541
Pennsylvania	11,801	11,864	11,958
New York	18,241	17,558	18,055
Total	81,813	83,806	86,958
Canada	21,568	24,343	27,297
United States	203,302	226,546	252,160

Sources: U.S. Bureau of the Census; Statistics Canada.

In 1991, the total population of the eight Great Lakes states plus Ontario stood at 86.9 million and included 30.5 percent of the U.S. population and 37 percent of the Canadian population. Hart suggests that this combined state/province population may have peaked around 1990 (1991, 28). In-basin population on the U.S. side has been essentially stable since 1970, while the Canadian in-basin population has continued to grow.

2.6 Hidden Costs

The history of economic development sketched above leaves a mixed legacy. In 1990, the combined value-added or gross state/province product of the eight Great Lakes states and Ontario stood at U.S. $1.9 trillion (Table 2). This figure is roughly twice the gross national product of the United Kingdom and three times that of Canada. Only Japan (U.S.$2.9 trillion) and the United States as a whole (U.S.$5.5 trillion) exceed the amount generated in the Great Lakes region (World Bank 1992, 222).

Table 2
Gross state and provincial product for the eight Great Lakes states and Ontario, 1990

State/province	Gross state/provincial product (millions US$ current)
Minnesota	100,005
Wisconsin	100,617
Indiana	111,851
Michigan	188,041
Ontario	209,500
Ohio	222,126
Pennsylvania	244,634
Illinois	272,197
New York	466,828
Total Great Lakes	1,915,799
Canada	667,843
United States	5,498,793

Sources: Bureau of Economic Analysis 1994; Statistics Canada 1992b, 1993b.

The region's intensive development brought a spectacular increase in the material standard of living (Testa 1991, iv). However, there have been hidden costs – paid for partly in human life but borne mostly by the Great Lakes basin ecosystem itself. Some of these costs are now appearing in the form of expenditures required to rehabilitate degraded land areas or water bodies, restore ecological functions, repair damage to private property, manage accumulations of buried waste, improve and/or replace a wide variety of built infrastructure, and cover the related costs of human health care.

Over the past century, the population of the Great Lakes has reacted to five environmental "crises" (modified from Colborn et al. 1990, xxiv-xxvi). These crises include widespread death from cholera and typhoid at the turn of the century; the destruction of the Great Lakes fishery; massive eutrophication; record-high lake levels in the mid-1980s, which led to extensive flooding, erosion of lake shorelines, severe damage to lakeshore properties, and contamination by persistent toxic substances. Together, these crises suggest a need for change – as if the ecosystem itself was providing a set of early-warning signals.

Crisis 1: Death from Cholera and Typhoid

In 1882, 180 people of every 100,000 in Ontario died of typhoid, cholera, or similar diseases

(Koci and Munchee 1984). In 1910, the death rate in U.S. Great Lakes cities of 100,000 inhabitants or more was averaging 23.75 deaths per 100,000 inhabitants, five times the rate recorded in similarly sized northern European cities (Sullivan et al. 1982, 95). Contamination of drinking water supplies with raw sewage was the cause. Chlorination of drinking water resolved the immediate problem; the epidemics passed and this first crisis appeared to end. However, little was done to halt contamination of lake waters and tests undertaken in the 1940s and 1950s (IJC 1951) showed that the levels of harmful bacteria were triple those found earlier in the century. It was not until the 1970s that municipal sewage treatment began to bring this problem under control.

Crisis 2: Collapse of the Fishery

In early settlement times, the Great Lakes teamed with abundant fish. With development, however, three factors threatened the fish populations simultaneously: competing exotic species introduced through the canal and shipping system (recent work has shown that 69 exotic species have been introduced of which 27 are a result of uncontrolled discharge of ballast water [Dochoda et al. 1990, 24]); degradation of water quality as a result of massive discharges of both nutrients and toxic contaminants; and overfishing. In the 1950s, the Great Lakes fishery collapsed.

The fishery has since been rebuilt and a multibillion-dollar sport fishery created. While on the surface, the crisis has been successfully overcome:

> *. . . the "quality" of fish has not recovered. Several key species including the lake trout, are no longer naturally self-sustaining and remain only because of expensive artificial stocking programs. New exotic organisms (with unknown impact on the ecosystem) continue to find their way into the Great Lakes in the bilge water of ships. Advisories warn against high levels of fish consumption because of toxic contaminants. Although fish have become readily catchable once again, whether they are fit for human consumption is questionable. (Colborn et al. 1990, xxv)*

Crisis 3: Eutrophication

By the 1960s, water quality degradation had reached an extreme, especially in Lake Erie. There, nutrient enrichment, mainly phosphorus from municipal and industrial sewage, had led to excessive eutrophication. In this process, abundant algae growth occurs. The algae then die, decay, and deplete the water of life-supporting oxygen.

The Great Lakes Water Quality Agreement of 1972 set targets for nutrient reduction. Funds were earmarked for sewage treatment infrastructure and controls on phosphorus discharges were introduced. By 1989, more than U.S.$10 billion had been spent. In many parts of the lakes (not all) the eutrophication problem has been brought under control (Colborn et al. 1990, xxvi). While the residual problems are still significant in many local areas, the reduction of the eutrophication problem to date represents a significant success story.

Crisis 4: Fluctuating Water Levels

In the mid-1980s, after some 20 years of above-average precipitation and below-average evaporation, water levels in all of the Great Lakes except Lake Ontario reached the highest levels of this century. Lake Superior reached levels one third of a metre above the long-term average, while lakes Michigan, Huron, and Erie rose a full metre above average.

When these conditions were combined with storm activity, the result was extensive flooding, erosion, and severe damage to lakeshore properties. Total costs of the damage ran into the millions of dollars (Levels Reference Study Board 1993, 1-2).

The Levels Reference Board (1993) points out that the financial and environmental costs of human regulation of lake levels to control damage far outweigh the benefits. However, underlying the Board's work is the message that the "crisis" of fluctuating water levels is really one of inappropriate land and shoreline use, use that has been allowed in the absence of any recognition of natural ecosystem conditions. In short, like the other crises listed here, the cause is human, not natural. The Board recommends the institution of comprehensive and co-ordinated land use and shoreline management programs.

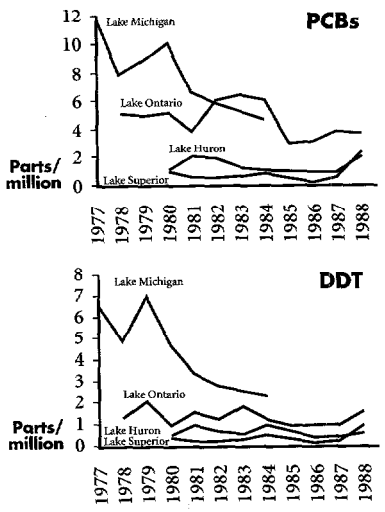
Crisis 5: Persistent Toxic Substances

The 1970s brought recognition of a new and much more complex chemical problem than eutrophication – persistent toxic substances. Toxic substances are substances that:

> *. . . can cause death, disease, behavioural abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances. (IJC 1988, 7)*

A *persistent* toxic substance is "any toxic substance that is difficult to destroy or that

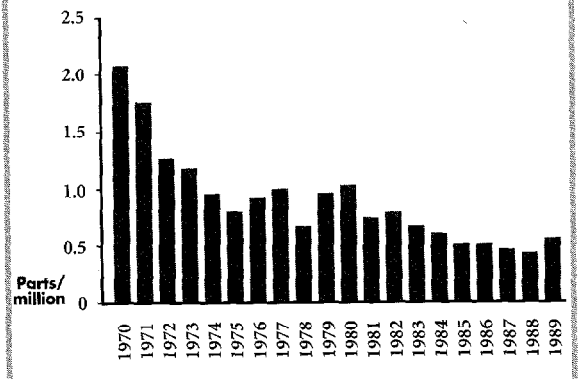
Figure 4
Concentrations of contaminants in lake trout from the Great Lakes, 1977-1988



Note: These are the average annual concentrations in parts per million net weight of total PCBs and DDT in whole lake trout. Fish from the Canadian lakes are four years of age; fish from Lake Michigan are between 620 and 640 mm in length.

Source: Environment Canada et al. 1991, Volume I, 13.

Figure 5
Average mercury concentration in walleye collected from Lake St. Clair, 1970-1989



Source: Virtual Elimination Task Force 1993, Volume II, 109.

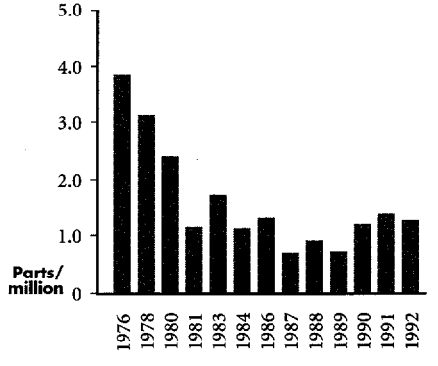
degrades slowly, i.e., with a half-life in water greater than eight weeks" (Environment Canada et al. 1991, 51).

Since the end of World War II, Western development has been characterized by an extraordinary increase in the use of manufactured chemicals.[1] Many of these are characterized by properties that allow them to gain entry into organisms and bioaccumulate as transfer occurs up the food web.

In 1978, the Great Lakes Water Quality Agreement was amended to add a focus on persistent toxic substances. Since then, a significant reduction in concentrations of contaminants has been observed – in water and in organisms. However, by the late 1980s, monitoring data indicated that the downward trend in concentrations of contaminants had levelled off and that in some cases increases were again evident. For example, Figure 4 shows concentrations of PCBs and DDT in lake trout from the Great Lakes between 1977 and 1988; Figure 5 shows the average mercury concentration in walleye collected from Lake St. Clair between 1970 and 1989; Figure 6 shows mean concentrations of PCBs in rainbow trout collected at the Ganaraska River between 1976 and 1992; and Figure 7 shows DDT concentrations in Lake Ontario rainbow smelt (whole fish) between 1977 and 1990.

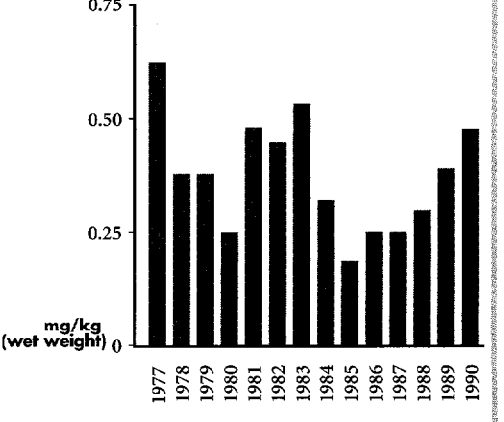
The kinds of trends shown above are cause for concern because injury to living organisms is still occurring despite reductions in concentrations of contaminants. For example, although the bald eagle has returned to the shores of the Great Lakes, its reproductive success is limited. Hatchery-reared lake trout introduced to the Great Lakes thrive but do not reproduce (Foran 1993, 6). A summary of contaminant-related effects on wildlife documented in the Great Lakes is provided in Table 3.

Figure 6
Mean concentrations of PCBs in rainbow trout collected at the Ganaraska River, 1976-1992



Source: Virtual Elimination Task Force 1993, Volume II, 109.

Figure 7
DDT concentrations in Lake Ontario rainbow smelt (whole fish), 1977-1990



Source: Virtual Elimination Task Force 1993, Volume II, 110.

There is growing evidence that the effects on wildlife listed in Table 3 are early warning signals of like effects on human beings. A summary of established linkages between persistent toxic substances and effects they cause is found in Table 4.

Of particular concern, many chemicals – such as DDT and its metabolites, dieldrin, PCBs, dioxin, polycyclic aromatic hydrocarbons (PAHs), lead, and mercury – have demonstrated the ability to disrupt the endocrine system of laboratory animals, producing the symptoms observed in wildlife and summarized below in Table 5 (Thomas and Colborn 1992, 365).

The disruption to the endocrine system appears to be a result of certain chemicals acting like the female hormone estrogen. These same hormonally active chemicals are now being found in human tissue as well (Thomas and Colborn 1992, 365). Particularly worrisome is the fact that the resulting developmental effects occur in the offspring of exposed parents, rather than in the parents themselves (Colborn and Clement [eds.] 1992, 2).

In 1990, 1992, and again in 1994, the International Joint Commission signalled its concern about this topic to the governments of Canada and the United States. Most recently, it reiterated that:

Table 3
Principal contaminant-related effects observed in Great Lakes wildlife

Species	Population decrease	Effects on reproduction	Eggshell thinning	Congenital malformations	Behavioural changes	Biochemical changes	Mortality	Alterations in recruitment
Mink	X	X	NA	NE	NE	NE	X	?
Otter	X		NA	NE	NE	NE	?	?
Double-crested cormorant	X	X	X	(X)		X	?	?
Black-crowned night-heron	X	X	X	X		X	?	?
Bald eagle	X	X	X	NE		NE	NE	?
Herring gull		X	X	X	X	X	X	
Ring-billed gull				X		NE	X	
Caspian tern		X		X	NE	NE		X
Common tern		X	X	X		X		
Forster's tern		X		X	X	X		
Snapping turtle	NE	X	NA	X	NE	NE	NE	NE

X = effects documented NA = not applicable NE = not examined
? = suspected since population declined
1. Observations marked with an X have been reported in the published literature.
2. Unpublished records of congenital malformations exist for the double-crested cormorant, great blue heron and Virginia rail.

Source: Environment Canada et al. 1991, Volume II, 563.

. . . mounting evidence continues to reinforce concerns about the effects of persistent toxic substances. Long-term exposure of fish, wildlife, and humans to these substances has been linked to reproductive, metabolic, neurological and behavioural abnormalities; to immunity suppression leading to susceptibility to infections and other life-threatening problems; and to increasing levels of breast and other cancers. Available evidence also points to long-term reproductive and intergenerational effects.

One growing concern is effects on endocrine systems. Research has shown persistent chemicals – such as PCBs, dioxins, atrazine, hexachlorobenzene, as well as other organochlorines, and PAHs – to be strongly implicated in the disruption of endocrine systems (producing estrogenic effects, for example) in laboratory animals and in wildlife. The

Table 4
Cause-effect linkages of persistent toxic substances

Contaminant	Species	Effect
DDE, dieldrin, PCB	Bald eagle	Eggshell thinning; embryo mortality; adult mortality
PCB	Forster's tern	Embryonic mortality; deformities
Dioxin, PCB, DDT	Double-crested cormorant	Embryo deformities; eggshell thinning
PCB	Snapping turtle	Embryo abnormalities; embryo mortality
PCB, dioxin	Mink and otter	Reproductive dysfunction
PAH	Brown bullhead	Liver and skin tumours
PCB	Lake trout	Unable to reproduce normally; hatchability and fry mortality
Dioxin, PCB, DDT	Herring gull	Embryonic mortality; porphyria; thyroid hyperplasia; Vitamin A depletion; deformities; feminization; poor parenting
PCB	Human offspring	Short-term memory deficits (visual, verbal, quantitative, pictorial); growth retardation; activity retardation
Lead	Human offspring	Hyperactivity; permanently reduced intelligence; neurobehavioural abnormalities
Mercury	Human offspring	Learning and motor skill deficits

Source: Virtual Elimination Task Force 1993, 93.

substances appear to act as artificial, external hormones that disrupt the normal balance of hormonal activity in animals (IJC 1994, 4).

On the basis of the "weight of evidence" provided by the many studies, the International Joint Commission concluded in 1992 that a causal relationship can be established between persistent toxic substances and injury to both wildlife and humans (IJC 1994, 10). It has strongly urged that input of these substances into the Great Lakes be stopped and that:

> *. . . the burden of proof must shift to the proponent (manufacturer, importer, or user) of the substance to show that it does not or will not cause the suspected harm, nor meet the definition of persistent toxic substance. (IJC 1994, 10)*

To emphasize the nature of the risks now being faced in the Great Lakes basin ecosystem, the Commission posed the following three questions:

- What if, as current research suggests, the startling decrease in sperm count and the alarming increase in the incidence of male genital tract disorders are caused in part by *in utero* exposure to elevated levels of environmental estrogens?
- What if, as current research suggests, the epidemic in breast cancer is a result in part of the great numbers and quantities of estrogen-like compounds that have been and are being released into the environment?
- What if the documented declining learning performance and increasing incidence of problem behaviour in school children are not functions of the education system? What if they are the result of exposure to developmental toxicants that have been and are being released into the children's and parents' environment, or to which they have been exposed *in utero*? (IJC 1994, 5)

It went on to point out that the implications of a yes answer to any one of these questions are overwhelming; if all of them were so answered, the implications would be catastrophic. These conclusions led the International Joint

Table 5
Observed disruption of the endocrine system in wildlife as a result of persistent toxic substances

Effect	Birds	Fish	Shellfish	Turtles	Mammals
Thyroid dysfunction	•	•			
Decreased fertility	•	•	•		•
Decreased hatching success	•	•		•	NA
Gross birth defects	•	•		•	
Metabolic abnormalities	•	•			•
Behavioural abnormalities	•				
Demasculinization/feminization	•	•			•
Defeminization/masculinization	•	•	•		
Compromised immune system	•				•

NA = not applicable

Source: Virtual Elimination Task Force 1993, 93.

Commission to describe this crisis as "the most significant problem to be confronted in the Great Lakes Basin Ecosystem" (IJC 1994, 6).

The Costs of Inaction

Each of these five "crises" has led to unexpected costs to society – costs in terms of human life and health, a degraded Great Lakes ecosystem, "property," and dollars. Only a tiny portion of these costs are factored into the estimates of gross state and provincial product that are used to assess "success" and which identify this region as a major player in the global market. In fact, it is a quirk of the systems of national accounting that expenditures to rectify these crises appear as a contribution to the growth of state, provincial, or national product. Further, many of these costs are not amenable to measurement in dollars.

However, to provide a crude context, tens of billions of dollars are estimated to be required for the initial clean-up of 43 "areas of concern" located around the perimeter of the Great Lakes (Davidson and Hodge 1989, 24).

Looking at the issue of buried hazardous waste reveals some startling figures. By 1989, the National Priority List of the U.S. Superfund program contained 890 hazardous waste sites, of which 116 are within the Great Lakes basin (Colborn et al. 1990, 61). Clean-up and management, in perpetuity, of buried hazardous waste, particularly in the Great Lakes states, will also likely cost tens of billions of dollars.[2]

2.7 Summary

The Great Lakes region may well be at a critical juncture in its evolution. The continuous population growth and economic expansion through the last century may be coming to an end. At the same time, there is a growing realization that the hidden costs of this success in terms of human life and ecosystem degradation must now be accounted for. Re-establishing an enhanced quality of life through ecosystem restoration is emerging as a key to economic renewal. From here on, the region can move into a phase of overall decline or change direction to achieve long-term stability in terms of both human and ecosystem well-being.

In sum, the Great Lakes basin ecosystem together with the area contained within the broader state/provincial boundaries, provides an ideal test case for the proposed system of reporting on sustainability.

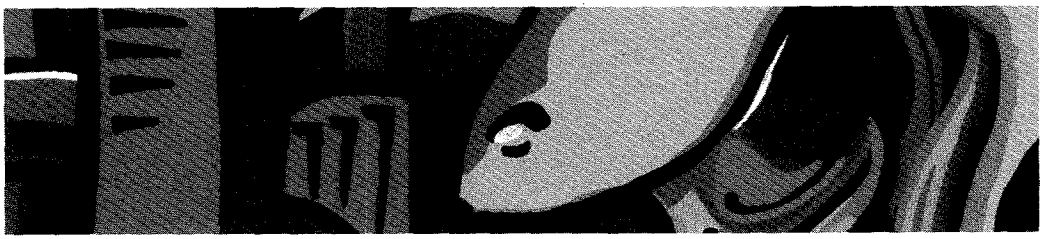
Endnotes – Section 2

1. Worldwide, about 10 million chemical compounds have been synthesized in laboratories since the beginning of this century. The European Inventory of Existing Commercial Chemical Substances (EINECS) lists 110,000 chemicals. In 1982, it was estimated that there were 60,000 chemical substances on the market and that the production of synthetic materials had increased some 350 times since 1940. This trend continued until the number of commercially available chemicals reached the 100,000 mark of today, with 1,000 new substances becoming available every year. Existing test facilities worldwide can only process half of these. In contrast to its small beginnings before World War II, the chemical industry in the late 1970s produced about 400 million tonnes of products a year and employed about four million people (UNEP 1992, 249).

   The International Joint Commission has developed a working list of 362 chemicals (both metals and organic chemicals) that are "considered to be unequivocally present" in the Great Lakes (Environment Canada et al. 1991, Volume I, 6).

   In 1977, the U.S. Fish and Wildlife Service identified nearly 500 organic compounds in adult lake trout and walleye collected from the Great Lakes. The number of synthetic chemicals detected in the basin's environment may be in excess of 1,000 (Virtual Elimination Task Force 1993, Vol. II, 89).

2. In 1988, and after a decade of lawsuits, a landmark decision of the United States District Court found Occidental Petroleum Corporation liable for the full cost of clean-up of the Love Canal hazardous waste site in New York's Niagara Peninsula. These costs were then estimated at U.S.$250 million and did not include costs of perpetual monitoring.



3. Systemic Assessment of Progress toward Sustainability in the Great Lakes Basin Ecosystem

3.1 Strategic Element I – Ecosystem

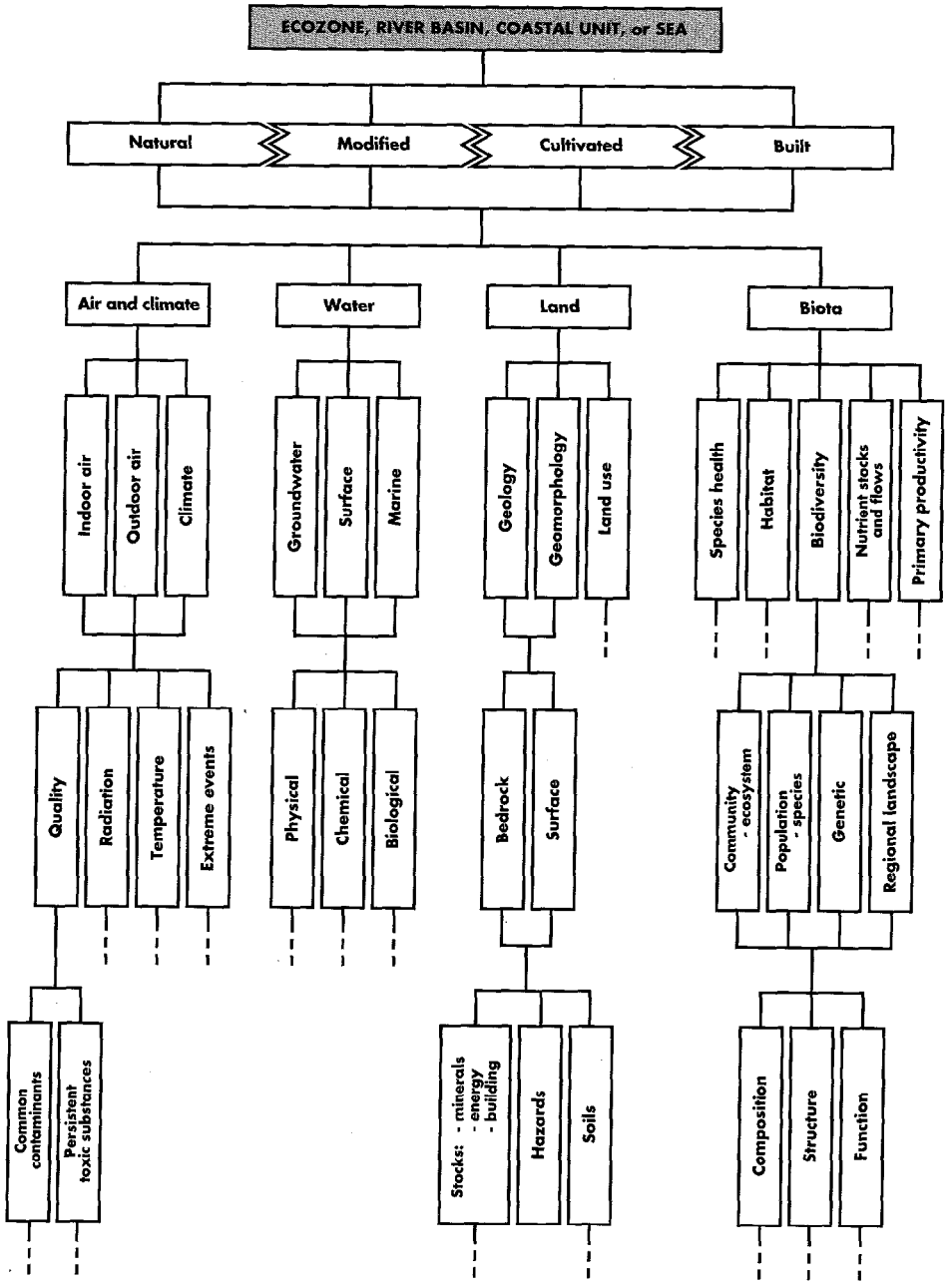
DOMAIN DESCRIPTION
Data and information facilitating an assessment of the integrity and health of the ecosystem.

GOAL
To maintain or improve ecosystem health and integrity.

To make an assessment of ecosystem integrity and health, a hierarchy of factors must be considered. An example assessment hierarchy for this domain is shown in Figure 8. It ranges from the most general category at the apex through a progressively finer level of detail toward the bottom. Specific measures are located at the very bottom. These assessment hierarchies provide a map of the assessment process. For example, Figure 8 shows that a comprehensive assessment of the health or integrity of a given ecozone or river basin requires consideration of its natural, modified, cultivated, and built subsystems.[1] Within each of these, air and climate, water, land, and biota must be assessed. Assessment of the water subsystem entails assessment of groundwater, surface water, and marine water, each of which must be considered in terms of water quality, water quantity, and temperature. And assessing each of these last factors can require the use of a large range of specific measures.

Working in the other direction, the concentration of a given contaminant is an indicator of water quality. In turn, water quality is one of several indicators of the overall state of the water subsystem. The state of the water subsystem is an indicator of, say, the modified component of the ecosystem, which itself is an indicator of the overall health and integrity of the ecozone or river basin. The assessment process builds from specific measures to the apex, drawing on the best available knowledge. This approach is no different from the judgment process ongoing every day in a court of law.

Figure 8
Assessment hierarchy for Area of Diagnosis I – Ecosystem



Source: Hodge 1995.

The particular assessment hierarchy shown in Figure 8 is one example of many that could be developed. It is important to emphasize that such hierarchies are not system models but maps of the assessment process.

An assessment of Great Lakes basin ecosystem integrity is summarized in Table 6, which lists 19 line items in eight categories. Each item contributes to the resulting assessment of ecosystem well-being. This exercise then feeds into the overall assessment of progress toward sustainability. Each line item is supported by a number of specific measures or indicators. In turn, each line item becomes an indicator for the more aggregated assessment to which it contributes.

Table 6 does not exactly mirror Figure 8, although ideally it would. Data and information limitations make such coincidence currently impossible. For example, an analysis that looks separately and comprehensively at the natural, modified, cultivated, and built components of the Great Lakes basin ecosystem has never been completed. Such an analysis is beyond the scope of this study.

The origins of Table 6 lie in the Great Lakes state-of-environment assessment documented in Colborn et al. 1990 (see especially 187-191). On the basis of their work, they conclude that:

> *despite regulatory vigilance to rein in polluters and significant government cleanup efforts over the past two decades, the environment of the Great Lakes basin is still in trouble. Dramatic evidence remains that the Great Lakes are imperiled by continuing habitat destruction and the long-term accumulation of toxic chemicals, which are increasingly pervasive throughout the ecosystem. (1990, xix)*

Similarly, the authors of *The State of Canada's Environment* conclude that:

> *despite the gains of the last two decades, the Great Lakes ecosystem is still threatened. Conditions for fish and other wildlife remain degraded, and human health as well as ecosystem well-being are at risk. Many bays, harbours, and channels remain severely degraded, and assessment of the cost of rehabilitating these degraded areas has brought to light a significant environmental "mortgage" of tens of billions of dollars. (Canada 1991, 18-28)*

Several important observations can be drawn from the above work. First, trends shown by indicators are not all in one direction. In this case, 4 suggest at least partially improving conditions (1a, 2a, 2b, 2d), 10 deteriorating or worrisome conditions (2c, 3a, 4a, 4b, 5a, 6a, 7a, 7c, 7f, 8a); and the remaining 5 suggest no change, uneven progress, or are not clear enough to assess (4c, 5b, 7b, 7d, 7e). Assessing and balancing these various indicators requires good judgment.

Second, specific standards, criteria, or targets that might facilitate a more exact assessment of a given topic exist for only a minority of these indicators. This lack does not impede an assessment. Trends that signal improvement or deterioration can be identified in the absence of such standards, criteria, and targets.

Third, data and information weaknesses can be identified in almost all of the 19 indicators. Of greatest concern are data describing toxic substances in the air and the groundwater system; the state of built infrastructure; wildlife health; plant health; and human health and well-being.

And last, while the compilation has been developed within a perspective of the whole ecosystem, not all ecosystem components are addressed. Rather, the 19 indicators provide a pragmatic compilation based on available data and information. Using Figure 8 as a systematic "check template," a number of gaps can be identified including assessments of indoor air quality, surface water quantity, a range of potentially useful bioindicators, and the stocks and flows of non-renewable resources.

Table 6
Indicators of Great Lakes ecosystem health and integrity

Factor	Response time	Basin limited	Current status/trend
1. Air quality			
a.	Days to months	No	Emissions data generally signal reductions over the last two decades that have likely contributed to an overall improvement, particularly for common pollutants such as SO_2 and suspended particulate matter. Hydrocarbon emissions and oxides of nitrogen have increased during this period. Conditions are periodically unacceptable in major cities, particularly because of ground-level ozone. Monitoring of airborne toxic substances is inadequate and additional concerns may be identified as air quality monitoring systems are upgraded.
2. Surface water quality (chemical and biological characteristics)			
a. Nutrients	Months to years	Yes	Excess nutrient problems in the Great Lakes proper have been greatly reduced since 1972, although trophic conditions are still not at targeted levels in some areas such as in the deep waters of Lake Erie. Eutrophication remains a significant problem in a number of nearshore areas and both eutrophication and acidification remain serious problems in many inland lakes. Concentrations of nitrogen compounds continue to rise – implications are not yet clear.
b. Toxic contaminants	Months to decades	No	Concentrations of toxic contaminants have generally declined over the past two decades, with some exceptions. Cumulative concentrations of metals in three of the Great Lakes are at elevated levels. Although concentrations of some persistent toxic substance meet ambient water quality standards, the processes of bioaccumulation and biomagnification mean that concentrations below water quality standards are still high enough to cause injury to fish, wildlife, and humans. Forty-three lakeshore "areas of concern," all of which are characterized by elevated contaminants in lake water, require a massive remedial effort. A similar assessment of inland locations within the basin has not been completed.

Table 6 – Cont.

Factor	Response time	Basin limited	Current status/trend
2. Surface water quality (chemical and biological characteristics) – cont.			
c. Loadings	Months to decades	No	Continuing point sources remain a concern, particularly the cumulative effect of all point sources. Both urban and rural non-point contaminant sources remain a serious problem.
d. Contaminated lake or river bottoms	Decades to centuries	Yes	Serious problem in 42 of 43 "areas of concern". In general, sediments deposited in recent centuries are less contaminant-laden, indicating an "improvement." However, bottom sediments remain a continuing source of contaminants and excess nutrients in the food web.
3. Groundwater			
a.	Decades to centuries	Yes	With pollution-prevention activities in their infancy and pollution sources increasing in both number and magnitude, it is likely that groundwater quality is degenerating. Degraded conditions will last long into the future. The groundwater subsystem is ill-understood.
4. Cultivated land			
a. Conversion of high-quality agricultural land to urban uses	Days to years	Yes	An overall loss of cultivated land is continuing although the loss per capita is decreasing over time, suggesting a slow improvement.
b. Soil productivity	Years to decades	Yes	Productivity is generally stable, although there is a growing concern regarding chemical inputs and their long-term implications.
c. Soil erosion	Months to decades	Yes	There is continuing natural erosion. Conditions are generally stable compared to those in other parts of North America.
5. Other special lands			
a. Wetlands	Years to decades	Yes	Two thirds of the original wetlands have been destroyed since the beginning of European settlement. Further destruction has been slowed but not stopped.

Table 6 – Cont.

Factor	Response time	Basin limited	Current status/trend
5. Other special lands – cont.			
b. Shorelines	Years to decades	Yes	There is continuing natural erosion. The inappropriate use of vulnerable shorelines is continuing, often leading to unnecessary damage to property.
6. The built environment			
a. Built infrastructure	Years to decades	Yes	There are growing concerns regarding the ongoing quality, maintenance, and replacement costs of a wide range of built infrastructure. No overall infrastructure assessment has been completed.
7. Biota			
a. Body burdens of persistent toxic substances	Intergenerational effects; decades	No	Significant improvements have been recorded since the early 1970s. However, since the late 1980s, trends have been inconsistent with a number of contaminants showing either little further change or an increasing trend. For many substances, levels remain above targets specified in the Great Lakes Water Quality Agreement or other guidelines and standards. Continued high levels of substances whose use has been restricted signal releases of contaminants previously deposited in the ecosystem, continued release from improper storage of waste and remaining stocks, or continuing use in remote areas outside the basin linked with a transport mechanism into the basin.
b. Population health status	Years to decades	No	Population health status is variable: some species are recovering, while some key species such as lake trout and eagles are still unable to establish self-sustaining populations. Biota remain threatened in acidifying inland lakes. Many populations are not well monitored and an overall assessment has not been completed.
c. Wildlife habitat	Days to centuries	Yes	All human-occupied land represents some loss of wildlife habitat. Blockage of creeks, streams, and rivers from dam construction has dramatically altered aquatic habitat. No overall assessment of aquatic and terrestrial habitat has been completed, although in recent decades the rate of loss and deterioration appears to have slowed.

Table 6 – Cont.

Factor	Response time	Basin limited	Current status/trend
7. Biota – cont.			
d. Forests	Decades to centuries	Yes	Many forests are maturing again after recovering from massive overcutting and fires during the 19th and early 20th centuries. Second-growth species and age distributions are markedly different from those of the original forests. Forests remain at risk from overcutting, airborne contaminants and potential climate change. No overall assessment of forest ecosystem health and integrity has been completed.
e. Health of plant communities	Months to decades	Yes	The health of plant communities is little monitored and geographic specific. There are clearly some concerns although no overall assessment has been completed.
f. Overall biological diversity	Decades to centuries	No	An initial assessment has identified 22 critically imperilled, 30 imperilled, and 79 rare ecological elements. Of these, 31 are natural ecological community types, 49 are plants, 21 are insects, 12 are mollusks, 9 are fish, five are birds, three are reptiles and one is a mammal. Ongoing human-induced stresses are cause for concern, and without stress reduction, biological diversity will continue to erode.
8. Human health and well-being (used as an indicator of ecosystem integrity)			
a.	Days to generations; decades	No	There is little indication that the health of adults is being compromised by toxic contaminants. Certain subgroups (children, child-bearing women, aboriginals dependent on country food) are at an elevated risk and there is growing concern regarding subtle chronic and intergenerational effects. Data are available that suggest that the overall state of well-being is not improving although average income levels continue to grow in real terms.

Sources: Colborn et al. 1990; Canada 1991; Environment Canada et al. 1991; IJC 1982, 1984, 1986, 1989, 1990, 1992, 1994; GLWQB 1989; Myers 1992; Thorp and Ballert 1991; The Nature Conservancy 1994.

This latter topic is part of the subject of natural resource accounting – a topic that has received significant theoretical attention in the last decade but has yet to find practical application in the Great Lakes region.

As it stands, Table 6 must be considered only as an initial step in undertaking a systematic Domain I assessment. Although the listed indicators facilitate an assessment of ecosystem health and integrity, each individual component requires more rigorous treatment. A complete assessment of the Great Lakes ecosystem would require original data. Collection of such data would be a major task and is well beyond the scope of this study. However, Section 5 provides a more detailed analysis of one ecosystem subsystem – water. It defines 23 indicators that deal with both the surface water and groundwater components.

Another approach to assessing ecosystem health and integrity is to identify characteristics of the Great Lakes ecosystem that have come to be recognized as signals of an ecosystem under stress (see Bird and Rapport 1986; Herricks and Schaeffer 1987; Canada 1991; Torrie Smith Associates and The Institute for Research on Environment and Economy 1993). Table 7 presents a list of stress characteristics that are evident in the Great Lakes ecosystem.

3.2 Assessment of Great Lakes Ecosystem Health and Integrity

Synthesis of the above material leads to a well-founded assessment of ecosystem health and integrity – in spite of the limitations in available data and information that have been identified. It is a weight-of-evidence assessment based on existing data and information. While improvements have been achieved in a range of ecosystem characteristics over the past several decades, the integrity and health of the Great Lakes ecosystem remain depressed.

Table 7
Biological characteristics indicating that the Great Lakes ecosystem is a stressed ecosystem

- Decline in the number of native species and in species diversity
- Decrease in system stability – stressed ecosystems tend to fluctuate more widely than unstressed similar systems
- Shift to more opportunistic species
- Reduction in average size of dominant biota – alteration in community structure to favour short-lived smaller life forms
- Unnatural rapid alteration in the quantity of either living or dead biomass
- Impaired biological productivity
- Changes in primary energy production and energy flow through the system
- Higher susceptibility to disease (except in instances where the stress weakens the disease more than the host) reflected in an increase in the prevalence of disease
- Enhanced leaching of nutrients in terrestrial ecosystems and their accumulation in recipient aquatic systems
- Enhanced circulation of contaminants and toxic substances and their bioaccumulation in the food web

Most importantly, current trends do not collectively signal that ecosystem health and integrity are being maintained or improved – the goal of this domain if progress toward sustainability is to be achieved.

3.3 Strategic Element II – Human-Ecosystem Interaction

DOMAIN DESCRIPTION

Data and information facilitating an assessment of the interaction between people and the ecosystem: how and to what extent human activities contribute to the provision of basic needs and to the quality of life; how these activities are valued; how these activities stress or contribute to restoring the ecosystem; and how successful we have been at meeting the goals and objectives of policies, regulations, and legislation.

GOALS

- To reduce the physical, chemical, and biological stress imposed on the ecosystem by human activities.
- To increase the extent to which human activities restore ecosystem health and integrity.
- To increase the ability of human activities to support human well-being.

Four related tasks lie at the core of the Domain II assessment: (1) identifying, classifying, and assessing human activities; (2) assessing their contribution to human well-being (their value or benefit); (3) assessing the stress they impose on the ecosystem; and (4) identifying their contribution to ecosystem restoration. The assessment hierarchy shown in Figure 9 provides the organizational template for addressing these four tasks.

Human Activities and Their Value

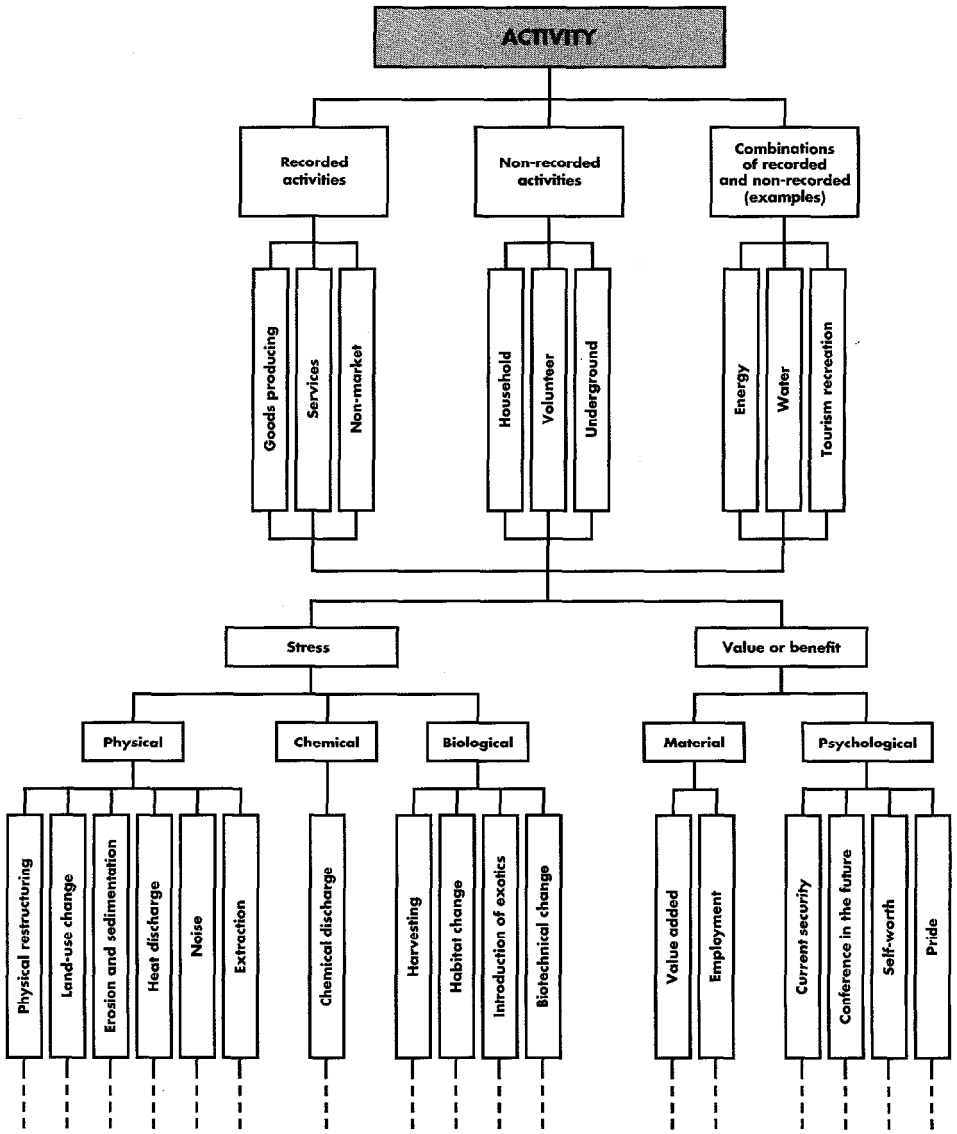
Classifying human activities and compiling figures for value added and employment provides a starting point for the first two of these tasks. Data for Ontario and the eight Great Lakes states are found in Appendix 1.

These data provide a picture of human activities and their relative "value" for a single year at a coarse level of aggregation. Finer-level data are available and time series extend at least 25 years. These numbers along with population and settlement trends provide the foundation for much more comprehensive regional macroeconomic analyses that consider trends in demographics, economic structure, the adequacy of support infrastructure, research and development effort, investment flows, and diversification. The most recently compiled synthesis for the region points out that population growth is now close to zero and economic restructuring is occurring in response to changing global conditions (Federal Reserve Bank of Chicago and the Great Lakes Commission 1991). It suggests that:

> *. . . the region's course lies in a more favorable direction in comparison to yesteryear . . . development policies and public discussion have changed from being reactive to being proactive, from adversarial to cooperative, and from inward-looking to global. This turnabout, in addition to the region's economic resurgence in the 1980s, has allowed the region's decision makers to make changes work for them rather than against them. (1991, vi)*

In short, there is optimism that past economic success can be extended.

Figure 9
Assessment hierarchy for Area of Diagnosis II – Human-Ecosystem Interaction



Source: Hodge 1995.

Human Activities and the Stress They Impose

The tables of Appendix 1 have an equally important second function. They provide a framework for assessing stress imposed by human activities on the ecosystem as well as restorative efforts initiated by human activities.

A summary assessment of human-induced stresses organized by stress type is provided in Table 8. Twelve indicators are listed that together enable an assessment of overall trends. Minor variations between the indicators on this table and the lower levels of the assessment hierarchy exist because of the nature of available data.

Like the elements of Table 6, the elements of Table 8 are supported by a large set of specific measures. The assessment is provided to demonstrate that the measures exist. A complete analysis of potential specific indicators for each item of Table 8 is beyond the scope of this case study. However, one important general observation can be made. Of the three stress types, imposed chemical stress has received the greatest emphasis, is the easiest to measure, and enjoys the greatest database. The idea of chemical pollution is popularly understood. In contrast, imposed physical and biological stresses are less understood, more difficult to measure, and are not generally well documented.

In this case, with the exception of the indicators showing a clear decrease through time in some point-source emissions of contaminants, all these indicators signal stress levels that are either increasing or, at best, stable. Thus the weight of evidence suggests an unsustainable trend.

Table 8 provides the key to identifying actions required to reduce stress on the Great Lakes ecosystem. Its limitation lies in the fact that it is only partially activity-specific and therefore only partially able to link to the activities listed in Appendix 1. To effect such an integration, an activity-by-activity stress assessment is required or, from another perspective, the cumulative stress assessment must be disaggregated by activity. Such a step is critical because it will facilitate identification of how activities might be altered to reduce stress. Standards, objectives, and criteria must be applied, and monitoring must be undertaken on an activity-by-activity basis. The concept of a broad stress assessment on an activity-by-activity basis is an important area for follow-up research.

While an overall stress assessment has never been completed, progress is being made toward one on a number of fronts. The current focus of assessment is on contaminant loadings and waste generation. Around the Great Lakes, a large number of comprehensive studies of pollution have been completed, some aimed at specific "areas of concern" and others aimed at larger study areas. As these investigations have evolved in the direction of action plans, more data have been gathered that are activity and establishment specific.[2]

A relatively comprehensive approach to pollution has been taken in the United States with the creation in 1986 of the Toxics Release Inventory (TRI). TRI is a computer-based system for tracking the release of 328 chemicals from manufacturing plants throughout the country. These facilities are required by law to report all direct releases to air, water, or land, as well as all releases that are transported to off-site facilities. The entire inventory, from facility-specific data to country aggregations, is available to the public in a computer database.[3] All data are classified according to the Standard Industrial Classification but are limited to the "manufacturing" line item in the tables of Appendix 1. In Canada, a similar

Table 8
Summary assessment of human-induced and natural stresses on the Great Lakes ecosystem

Physical stress

1. Physical restructuring

The major physical restructuring likely occurred historically with the removal of forests and clearing of land, the damming of streams, and the building of roads and other transportation arteries that limited the continuity of the natural ecosystem. There is growing concern with ongoing expansion of urban areas. Localized environmental concerns are often addressed in new projects, but little broad ecosystem perspective is used in current practice in private or public decision making. For example, decisions regarding shoreline development rarely consider long-term fluctuations of lake levels; moreover, wetland drainage to facilitate development is still occurring, although programs to stop this practice and rehabilitate wetlands are now in place.

2. Soil erosion and sedimentation

Soil erosion on agricultural lands, with subsequent removal of eroded soil in runoff and its deposition in water courses, is ongoing, and the volume of transported soil is considerable. In the early 1980s, rates of erosion in the agricultural areas of the U.S. Great Lakes basin were assessed to be largely at or below the "tolerable loss rate," although long-term soil productivity is not necessarily assured.[4] In Ontario, non-farm off-site costs of agricultural soil erosion have been estimated at $74-$91 million per year.[5] Programs have been established in the last five years in most parts of the Great Lakes basin to minimize soil loss from agricultural practices. These initiatives have been limited in both scope and impact.[6]

Erosion and sedimentation are also a by-product of construction activities. An overall assessment of erosion and sedimentation in the Great Lakes basin has never been completed.

3. Heat discharge

Thermal loading is likely increasing as a function of increased human activity associated with population growth. No overall assessment for the region has been completed.

4. Noise

Noise levels are likely increasing in most urban areas as a function of increased human activity associated with population growth. Noise is a particular problem alongside busy transportation corridors and some industrial facilities. No overall assessment for the region has been completed.

5. Water withdrawals

Current requirements for water extraction from surface water can be met by available renewable supplies. Pressure to increase water diversion both into and out of the basin can be expected, particularly if the projected effects of global warming occur.

Severe local problems exist due to mining of groundwater resources.[7]

Table 8 – Cont.

6. Extraction of non-renewable resources

Extraction of petroleum products, coal, minerals, and building materials is ongoing. An assessment of the short- and long-term implications of current extraction rates and the overall state of the stocks of these resources has not been completed.

Chemical stress

7. Contaminant loadings

Some point-source emissions to air and water in the basin are declining but serious ongoing discharges remain.[8]

Out-of-basin point sources are becoming increasingly significant contributors to contamination within the basin.[9]

Non-point sources are stable at best, perhaps getting worse.[10] They have emerged as the dominant source of both conventional and toxic contaminants.

Accidents leading to unanticipated spills or emissions continue to be a significant concern.[11]

8. Waste generation and storage

Hazardous wastes

In 1985, hazardous waste generation in the eight Great Lakes states and Ontario was estimated at 56.5 million tonnes (62.2 million tons). Time-series data are not available to signal trends in the volume and severity of generated waste. Management of hazardous waste sites, including clean-up, represents a large and growing drain on the economy. In 1989, the United States Environmental Protection Agency listed close to 3,600 sites in the Great Lakes basin that either cause or have the potential to cause environmental harm. The National Priority List of the U.S. Superfund Program lists 116 sites within the Great Lakes basin. In Ontario, 3,850 active and inactive waste sites have been identified, of which 80 percent are in the Great Lakes basin. Of those in the basin, 1,748 are thought to have the potential to pose health hazards to humans.[12]

Municipal solid wastes

In statistical terms, each of the 35 million residents in the Great Lakes basin generates about 2 kilograms (4.5 pounds) of municipal waste per day. These wastes are generated by households, industries, commerce, and government. They are a problem not only because of the sheer volume generated but also because of environmental stress from subsequent leachate. Most of this waste is deposited in landfills with a small proportion being incinerated or recycled. Existing disposal sites are almost at capacity in many areas, and disposal costs are increasing rapidly. Some local programs to "reduce, reuse, and recycle" have achieved some success in reducing waste generation. An overall assessment for the eight Great Lakes states, Ontario, and the basin has not been completed.[13]

Table 8 – Cont.

Biological stress

9. Harvesting of renewable resources

Forestry
Over the past two centuries, human activity – clearing for settlement, agriculture, human-induced wildfire, and commercial harvesting of forests has radically altered the original forest cover. Vast tracts of second-growth forest have emerged that are ecologically young and biologically complex.[14] Second-growth tree species are generally less valuable than the original old-growth species. Ongoing harvesting practices are subject to much debate. Shifting values and increased public pressure are leading to adjustments in forest practices that reduce stress and are more sensitive to ecological principles and non-commercial values.[15]

Fishing
Commercial fishing is at levels far below historical highs, while the popularity of sport fishing has exploded in the last two decades.[16] Fish communities have changed dramatically since 1900 and, although the changes differ in degree and type, depending on the lake, the result has been a general decline in the high-value native fish species – a decline often accompanied by an increase in low-value fish species. Efforts to reintroduce the lake trout by stocking have been successful, but the fish are not reproducing except in Lake Superior.

Hunting and trapping
Stress imposed by terrestrial wildlife harvesting (trapping and hunting) has never been assessed in terms of the overall robustness of the wildlife population; however, fur-bearing and game species are monitored by government agencies and harvest levels are limited to maintain populations.

Farming – soils
Soil productivity in farmed areas appears to be stable in the region but no long-term assessment has been completed.

10. Habitat change
Ongoing habitat change involving a range of physical, chemical, and biological stresses continues with expanded levels of human activity in the basin. No overall assessment has been completed but recent work has identified 3 critically imperilled, 8 globally imperilled, and 20 globally rare natural communities.[17]

Table 8 – Cont.

Biological stress – cont.

11. Introduction of non-native organisms

Some 69 exotic organisms have been reported in the Great Lakes ecosystem since the late 1800s. Twenty-seven of these have been introduced through the discharge of ships' ballast water.[18] These exotics have severely disrupted the Great Lakes basin ecosystem.[19] Volunteer programs are in place to control ballast discharge but concern remains regarding the entry of detrimental exotic species into the system.

12. Biotechnological change

No assessment of the environmental stress imposed by biotechnological change has been undertaken.

Sources: Colborn et al. 1990 plus specific sources listed in the endnotes.

database, the National Pollutant Release Inventory (NPRI), is now under development. It is currently (1994) in its first year of data gathering.

The direct tie to human activities through the use of the Standard Industrial Classification is an important characteristic of both TRI and NPRI. This simple step will ultimately make possible a comprehensive accounting of imposed environmental stress for any given activity and do so in a way that facilitates comparison of the stress with economic benefits.

TRI and NPRI are far from comprehensive. They deal only with a limited set of chemical stresses and a limited number of human activities. In spite of these limitations, they represent a beginning and they set a very clear direction for future effort.

Human Activities that Restore Ecosystem Well-Being

The concept of ecosystem restoration as a science (and art) is in its infancy.[20] Certain actions – such as the setting aside of land for parks and protected areas, reforestation, providing fish-ladders around channel blockages, restoring fish spawning grounds, restoring migratory bird staging and nesting habitat, and restoring water and air quality – all qualify as restoration activities.

In 1946, the Ontario Legislature passed the Conservation Authorities Act (R.S.O. 1946, Chapter 133) creating the Conservation Authorities Program. Thirty-eight watershed-based conservation authorities have since been created, largely located in southern Ontario and covering 90 percent of the population of Ontario. From their beginning, these have been seen as a mechanism to enable comprehensive water management and provide "a new approach to conservation planning" (Shrubsole 1989, 8). There is no equivalent mechanism in the eight Great Lakes states.

Concern for conservation and restoration, particularly of renewable resources, played a key role in the lead up to and design of the Conservation Authorities Act (Shrubsole 1989, 105). However, there has never been an overall assessment of conservation authority activities

Table 9
Beneficial uses as defined in the Great Lakes Water Quality Agreement

"Impairment of beneficial use(s)" means a change in the chemical, physical, or biological integrity of the Great Lakes system sufficient to cause any of the following:

- restrictions on fish and wildlife consumption;
- tainting of fish and wildlife flavour;
- degradation of fish and wildlife populations;
- fish tumours and other deformities;
- bird or animal deformities or reproduction problems;
- degradation of benthos;
- restrictions on dredging activities;
- eutrophication or undesirable algae;
- restrictions on drinking water consumption, or taste and odour problems;
- beach closings;
- degradation of aesthetics;
- added costs to agriculture or industry;
- degradation of phytoplankton and zooplankton populations;
- loss of fish and wildlife habitat.

from the perspective of ecosystem restoration. In fact, there is no centralized information system that facilitates a review of conservation authority activities.

Restoration has been formally entrenched in the Great Lakes Water Quality Agreement. Annex 2 of the amended Agreement (GLWQA 1987) addresses remedial action plans (RAPs) in 43 designated "areas of concern" and lakewide management plans (LMPs). The intent of the Agreement is to protect human health and ecosystem integrity (GLWQB 1989, 61). Assessment of whether or not human health and ecosystem integrity are indeed being protected is tied to the concept of "impairment of beneficial use(s)." Beneficial uses are listed and defined in Table 9.

From 1987 to 1991, the Great Lakes Water Quality Board maintained a responsibility for monitoring and reporting on progress in the development and implementation of the remedial action plans and lakewide management plans. Subsequently, that responsibility was returned to the parties to the Agreement (GLWQB 1993, 1). Unfortunately, since that shift in roles occurred, no comprehensive reporting on progress has taken place. In its last RAP assessment, the Great Lakes Water Quality Board emphasized concern over the lack of progress in developing and implementing the remedial action plans.

The above fragmented discussion of restoration reflects the lack of any overall inventory of activities and assessment of progress. On the other hand, public interest

in restoration activities is growing and the number of restoration projects is increasing as communities move to rehabilitate degraded areas. These actions are motivated not only by aesthetics and the desire for an enhanced quality of life but also by the recognition that they are a contributor to economic renewal as well.

In sum, restoration activities appear to be increasing but the overall level of effort and success has never been inventoried and assessed. No system for tracking progress is in place. Together, these gaps represent important topics for follow-up research.

3.4 Assessment of Human-Ecosystem Interaction in the Great Lakes Basin Ecosystem

Using the weight-of-evidence approach, conclusions can be drawn regarding the nature of human activities and the "value" they contribute to society – at least in economic terms. In the Great Lakes region, there is every reason to believe that human activities will be able to maintain or even increase their contribution to human well-being in an economic sense. Description, classification, and valuation of the broad range of monitored and non-monitored human activities using economic and other valuation approaches are all topics of current research.

Similarly, reasonably well-founded conclusions can be drawn regarding the nature and extent of human-imposed stress on the ecosystem. Overall, it appears that imposed stress is likely on the increase. However, the data are only beginning to be generated that link specific stresses to the human activities that impose them. Thus the topic of activity-by-activity stress assessment emerges as a significant area of needed research.

An overall inventory and assessment of restoration activities in the Great Lakes basin ecosystem has never been undertaken. However, the number of restoration activities appears to be growing as public interest increases. Tracking and assessing restoration activities also emerges as an important area of needed research.

3.5 Strategic Element III – People

DOMAIN DESCRIPTION
Data and information facilitating an assessment of the well-being of people, including the range of physical, social, cultural, and economic attributes.

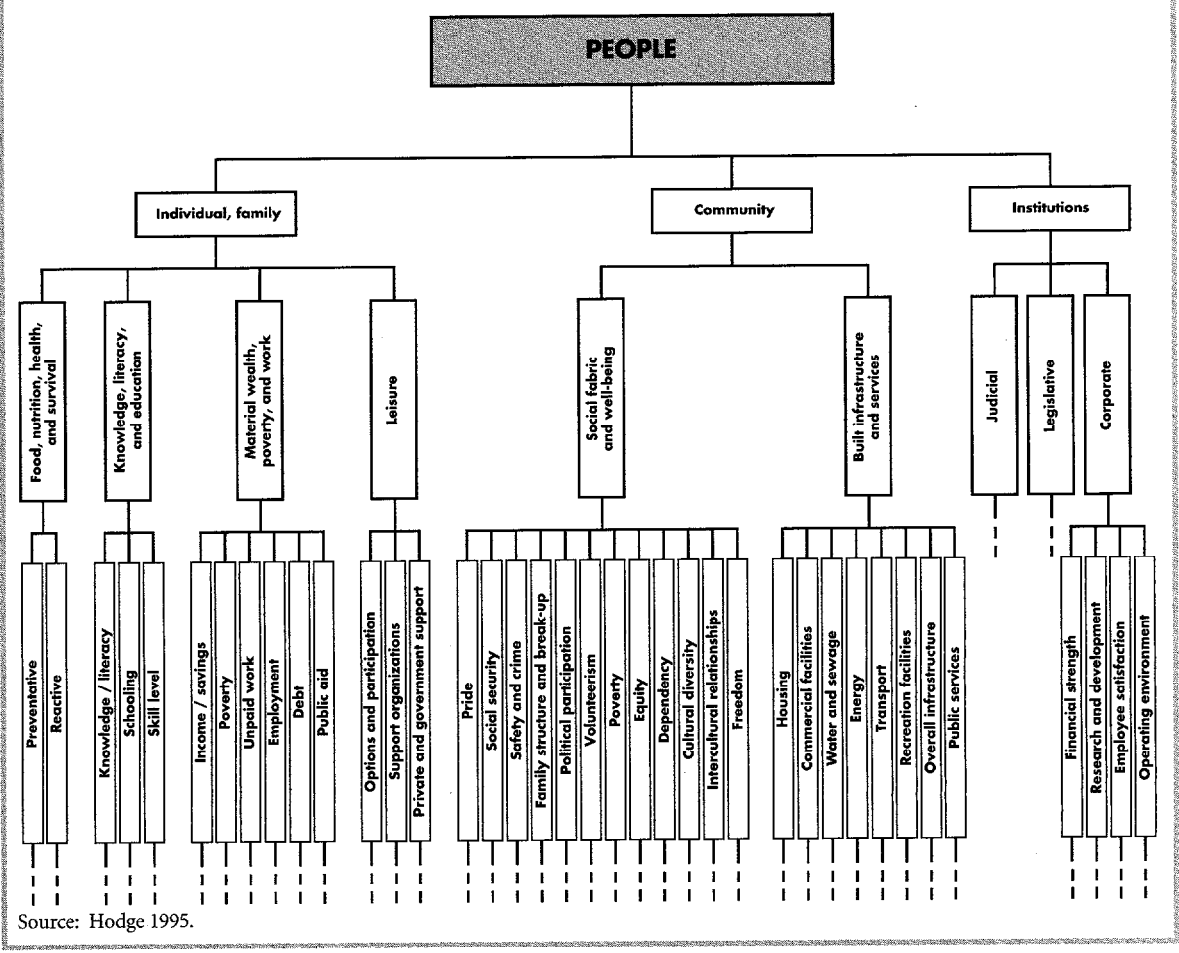
GOAL
To maintain or improve human well-being.

The Domain III assessment includes consideration of the well-being of individuals and families; communities;[21] and institutions. Institutions include legislative, judicial, and corporate bodies.[22] The assessment hierarchy shown in Figure 10 provides the organizational template.

While data are available for many of the most detailed topics at the base of the indicator hierarchy shown in Figure 10, no systematic attempt has been made to bring this knowledge together and assess current, past, and anticipated future trends in human well-being across the Great Lakes basin ecosystem. Further, there are two significant gaps.

First, society has not developed a systematic approach to assessing the well-being of legislative and judicial institutions. From time to time, relevant data are compiled that show, for example, that courts

Figure 10
Assessment hierarchy for Area of Diagnosis III – People



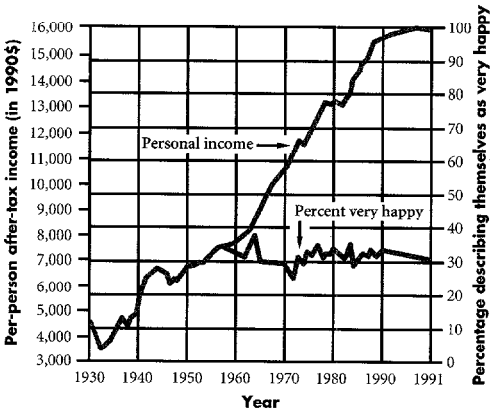
Source: Hodge 1995.

or penitentiaries are overcrowded or that respect for legislators has plummeted. But no system has ever been established to set goals for these institutions and to develop measurable objectives that allow society to assess success.

Second, the required assessment of human well-being is complex and well beyond the limits of this case study. Conditions and trends change over time as do the values that influence both individual and collective interpretation of those conditions and trends. In spite of the difficulties, the assessment of human well-being emerges as one of the most important recommendations for follow-up research.

Even though a systematic assessment has not been completed, two sets of observations are worthy of note. First, drawing from macroeconomic analyses, Testa points out that above-average per capita income persisted through the 1970s and "the region's intensive

Figure 11
After-tax income and happiness, 1930-1991



Source: Myers 1992, 42.

development provided a standard of living that had not been previously witnessed on so massive a scale" (1991, iv). This kind of observation suggests a high degree of human well-being.

However, over the past several decades, a growing volume of literature has emerged that challenges the correlation between material prosperity and overall well-being. Myers points out that between 1960 and 1990, after-tax income doubled in the United States, while self-assessed "happiness" remained unchanged (see Figure 11).

Myers also points out:

Today's younger adults have grown up with more affluence, more depression, and more marital and family misery. They also know more of depression's consequences – suicide, alcoholism, and other forms of substance abuse.

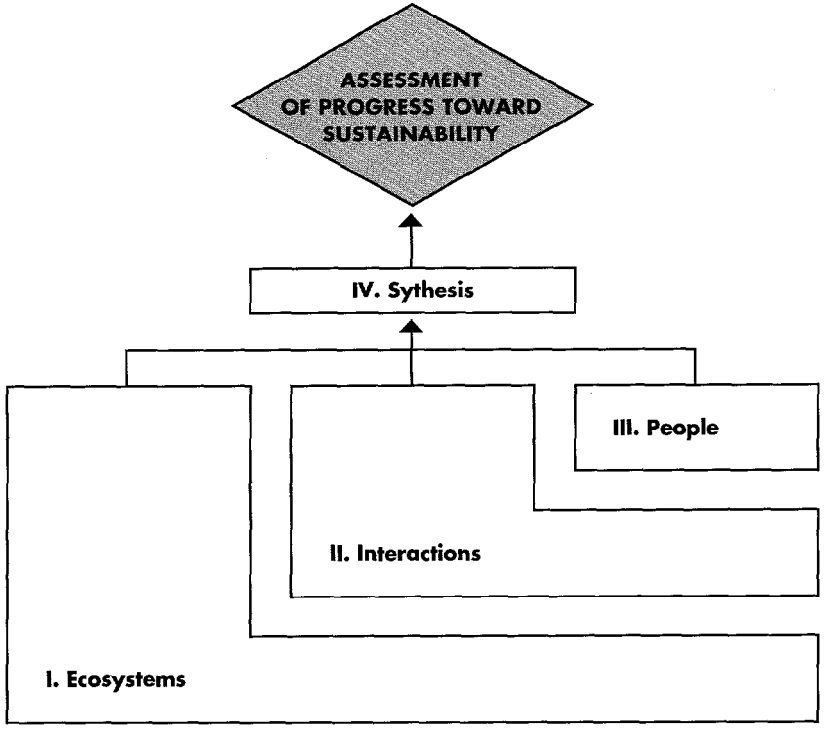
The same story holds true for the social well-being of adolescents. Between 1960 and the late 1980s, America's teens enjoyed the benefits of declining family poverty, smaller families, increased parental education, doubled per-pupil school expenditures (in constant dollars), double the number of teachers with advanced degrees, and an 11 percent drop in class size. Simultaneously, their delinquency rate doubled, their suicide rate tripled, their homicide rate tripled, and the birthrate of the unmarried nearly quadrupled. While standing tall during the 1980s believing a comfortable lie that all was well in a prosperous and militarily successful America, the uncomfortable truth was that social battles were being lost at home. (Myers 1992, 43)

3.6 Assessment of Human Well-Being in the Great Lakes Basin Ecosystem

Myers' observations likely apply in the Great Lakes region as elsewhere. However, what is most important is that they challenge the commonly held concept that economic indicators of success always point to improved well-being. For this case study, they serve to bring emphasis to the need to undertake a systematic assessment of human well-being.

A second insight emerges from this Domain III assessment. It is that the natural boundary for Domain III analysis will almost inevitably be the secondary decision-making envelope rather than the primary ecosystem focus (see Figure 1). Data are compiled and emphasis for decision making will be weighted on this basis. In the Domain IV synthesis, this difference would have to be carefully weighed in the assessment process.

Figure 12
Assessment hierarchy for Area of Diagnosis IV – Synthesis



Source: Hodge 1995.

3.7 Strategic Element IV – Synthesis

DOMAIN DESCRIPTION
Data and information facilitating the recognition of emergent system properties and providing an integrated perspective for decision making and anticipatory analysis that spans domains I, II, and III.

OVERALL GOAL:
To maintain or improve human and ecosystem well-being.

The assessment hierarchy shown in Figure 12 provides the organizational template for undertaking the Domain IV synthesis. A summary of goals and principal conclusions drawn from the assessments for Strategic Elements I, II, and III is presented in Table 10.

3.8 Assessment of Overall Progress toward Sustainability in the Great Lakes Basin Ecosystem

Five assessment elements are listed in Table 10. Together they amount to a short list of indicators of sustainability. Each is supported

Table 10
Synthesis of goals and assessments, Strategic Elements I, II, and III

Goal	Assessment
Domain I – Ecosystem	
1. Ecosystem well-being: To maintain or improve ecosystem health and integrity.	While improvements have been achieved in a range of ecosystem characteristics over the past several decades, ecosystem integrity and health remain depressed. Current trends do not collectively signal that ecosystem health and integrity are being maintained or improved.
Domain II – Interaction	
2. Support: To maintain or increase the ability of human activities to provide support for human well-being.	Human activities will be able to maintain or even increase their contribution to human well-being. Continued economic success as signalled by growth in value added and employment can be expected.
3. Stress: To reduce the physical, chemical, and biological stress imposed on the ecosystem by human activities.	The combined physical, chemical, and biological stress imposed on the ecosystem by human activities is likely increasing.
4. Restoration: To increase the extent to which human activities restore ecosystem health and integrity.	Restoration activities are likely increasing as public interest grows. No overall inventory and assessment has been completed; no overall tracking system is in place to monitor and assess progress.
Domain III – People	
5. Human well-being: To maintain or improve human well-being.	No systematic assessment of trends in human well-being in the Great Lakes region has been completed. A growing body of literature points out that once people are beyond poverty, further economic growth does not appreciably improve their morale.

by a complex hierarchy of data and information that are scientifically defensible. In spite of limitations in current knowledge, the weight of evidence from these five indicators signals that the Great Lakes basin ecosystem is not currently on a path toward sustainability. In particular, ecosystem health continues to deteriorate and imposed stress continues to grow. An overall assessment of trends in human well-being is lacking, not only

in terms of individual well-being but also in terms of the well-being of communities and institutions. On the positive side, the ability of human activities to support human well-being from a material perspective appears to be growing and the number of initiatives aimed at ecosystem restoration is likely increasing.

It is essential that this kind of an assessment be put into a long-term historical context. For example, while (first order) trends in ecosystem conditions and imposed stress indicate movement away from sustainability, it is also apparent that many factors exhibit second-order change that is positive. For example, the rate of waste generation may still be growing but at a rate that is slower than, say, three decades ago. In a comprehensive analysis, these longer-term characteristics would be carefully established and assessed.

Similarly, in a comprehensive analysis, the implications of current trends for future conditions would also be considered. For the very short term of a year or two, this component of the analysis could contribute to predicting the requirements for, say, public expenditures on infrastructure. In the longer term, alternative scenarios might be constructed against which to test current public policy. Most powerfully, the anticipatory analysis can be used as a component of an exercise that designs needed present-day policies by starting with a future desired state and "backcasting" to current conditions.

While some scenario analysis has been completed for the Great Lakes basin from time to time (e.g., see GLBC 1975) and backcasting has been specifically used as an approach to energy analysis for Ontario (e.g., see Torrie 1984), these approaches have not yet been applied to assessing progress toward sustainability in the Great Lakes basin ecosystem.

3.9 Focus on Energy and Water

The preceding discussion illustrates the general application of the proposed system of reporting on sustainability. It has focussed on the process of achieving a final integrated assessment of progress toward sustainability. What remains is to demonstrate application at a more detailed level. To do so, two subsystems will be examined, energy (production, transportation, and use) and water.

Endnotes – Section 3

1. The natural, modified, cultivated, built classification is proposed by Robert Prescott-Allan and is described in IUCN et al. 1991, 34.

2. Reports that include such data include the final report of the Niagara River Toxics Committee (1984), the Niagara River Toxics Management Plan (Niagara River Secretariat, 1988, 1990), the Lake Ontario Toxics Management Plan (Lake Ontario Toxics Committee, 1989), the final report of the Upper Great Lakes Connecting Channel Study (UGLCCS 1988), many of the reports completed in development of the remedial action plans for the 43 "areas of concern" in the Great Lakes basin, and the base data reports gathered in development of Ontario's Municipal-Industrial Strategy for Abatement (MISA) program. Almost all of these focus on contaminant emissions to water.

3. USEPA 1989.

4. The "tolerable loss rate" is defined as the maximum rate at which soil can be eroded and maintain productivity. There is much debate about whether or not this rate assures long-term productivity (see Colborn et al. 1990, 44).

5. Development Consulting House and Land Resource Research Institute 1986.

6. Colborn et al. 1990, 44.

7. Extreme cases of groundwater mining have taken place in the Chicago-Milwaukee area. The Lake Winnebago area and Green Bay, Wisconsin are other examples. It appears to be an emerging problem in growing suburban residential areas of southern Ontario (Hodge 1990, 451-452).

8. In 1993, the Science Advisory Board of the International Joint Commission concluded that "after seven decades of initiatives to clean up toxic pollutants in the Great Lakes, there are insufficient data to measure past success and establish the benchmarks needed to direct future efforts. Data that is available does not substantiate success of these initiatives" (SAB 1993, 9).

9. GLWQB 1991, 42.

10. Non-point or diffuse sources include contaminated aquatic sediments, urban runoff, the broad use of chemicals in agriculture, forestry, and transportation; vehicular emissions; and general contaminants in rain, snow, and dry atmospheric fallout from all sources.

11. Although data on spills are sketchy, there appear to be approximately 3,000 significant accidental releases of hazardous substances per year in the eight Great Lakes states and Ontario. These accidental releases may significantly exceed the impact of regulated point-source discharges. One analysis of two styrene spills into the St. Clair River found them to be equivalent to the pollution loadings of 1,428 and 58 years of the respective point-source discharges (SABTC 1988, 2- 3).

12. Colborn et al. 1990, 60-66.

13. Ibid., 66-71.

14. Shands (ed.) 1988; Shands and Dawson 1984; Scarratt 1988.

15. The dramatic shift in attitude toward forests that occurred between about 1950 and 1980 is discussed by Hays (1983). Thompson and Webb (1994) document the results of a Forest Round Table (which brought together industry, labour, environmental groups, and community representatives from across Canada) that was specifically aimed at dealing with alternative value sets regarding forests. This kind of bridging would never have occurred even 10 years ago.

16. In 1985, the land value of commercial fishing in the Great Lakes was about $41 million, while sport anglers were estimated to have spent $2 billion in the same year (Colborn et al. 1990, 150).

17. The Nature Conservancy 1994, 15-19.

18. Entry vectors of exotic species introduced in the Great Lakes since the late 1800s include:

Vector	No. of exotic species introduced
Waterfowl, birds	8
Range expansion	3
Infected fish	2
Fish stocking	11
Canals	3
Bait/culture	5
Unknown	10
Ship ballast water	27
Total	69

Source: Dochoda, Hamilton, and Bandurski 1990, 24.

19. For example, the sea lamprey has devastated lake trout populations and annual direct expenditures on lamprey control now amount to $10 million. Costs of controlling the recently introduced zebra mussel may reach $100 million annually (IJC and GLFC 1990, 1-2).

20. The Society for Ecological Restoration held its first annual conference in 1989. It is committed to the development of ecological restoration as a science and art – a conservation strategy and a way of defining and celebrating a mutually beneficial relationship between human beings and the rest of nature. It publishes a biannual journal, *Restoration and Management Notes* (1207 Seminole Highway, Madison, Wisconsin, 53711 USA). The topic was reviewed 9 and 16 March, 1992, on CBC's "Ideas".

21. Daly and Cobb point out that a group of people can be called a community if:

a) membership in the group contributes to self-identification;

b) there is extensive participation by its members in the decisions by which its life is governed;

c) the group as a whole takes responsibility for its members; and

d) this responsibility includes respect for the differences among these members (1989, 49 and 172).

Using this definition, a community could be based on a range of motivating factors such as ethnicity, gender, religion, geography, politics or interest. However, typical community statistics are gathered, not on the basis of these factors, but on the basis of a local government jurisdiction. Strictly speaking, such a local government is an incorporated institution. However, particularly in small communities, the local government reflects, at least to some extent, the local community as defined by Daly and Cobb above. Thus in the present study and as an initial position, community and local government were treated as one. This topic requires further research.

22. Institutions include:

a) legislative: those that make the rules by which society governs itself;
b) judicial: those that interpret and apply the rules;
c) corporate: those that are formally incorporated under some piece of legislation including:
   - for-profit businesses;
   - not-for-profit voluntary organizations, churches, and trusts;
   - professional associations;
   - co-operatives;
   - hospitals;
   - unions; and
   - universities, colleges, and community colleges.

Government functions both as a rule maker and a corporate entity. In the first of these functions, it must concern itself with the entire ecosystem, including people, within its boundaries. As a corporate entity it has internal responsibilities no different from those of any other corporation. These two functions are often confused, particularly from a reporting perspective. For example, from a financial perspective, the federal government must monitor itself as a corporate entity dealing with income, expenditures, deficits, and so forth. This aspect of reporting is very different from reporting on the national economy, in which the federal government is only one player, albeit a significant player (see discussion in NRTEE 1993, 41-46).

4. Energy Production, Transportation, and Use in the Great Lakes Basin Ecosystem

4.1 Introduction

Energy production, transportation, and use are obvious foci for assessing progress toward sustainability. These essential activities impose a high degree of stress on the ecosystem. There are a limited number of energy sources and forms, and security of supply is both a national and regional concern.

In this case study, energy production, transportation, and use are included as examples of human activities within Domain II. They include monitored and non-monitored activities and thus show as "combinations" on the Domain II assessment hierarchy (Figure 9).

The three Domain II goals provide a general assessment framework. Restated in terms of energy, they are:

- to maintain or increase the ability of energy production, transportation, and use to support human well-being;
- to reduce the physical, chemical, and biological stress imposed on the ecosystem by energy production, transportation, and use; and
- to increase the extent to which energy production and transportation activities can be modified or directed to facilitate restoration of ecosystem health, integrity, and well-being.[1]

Any given activity uses energy both directly and indirectly and thus there are both direct and indirect environmental implications. Direct energy use encompasses energy consumed as part of any activity itself. In contrast, indirect energy use includes (1) energy consumed during prior contributing activities; and (2) energy used in the creation of the capital used in the current activity (see discussion in Brooks 1981, 278-279).

For example, direct energy used in agriculture would include farm heating, lighting, and equipment fuel, while the energy used to manufacture the farm equipment and produce fertilizers and pesticides is considered indirect energy. Analysis of any activity should be sensitive to total energy use as part of full-cost accounting. However, only direct energy use is considered here. Analysis of total energy use (direct plus indirect) is beyond the resources available for this case study.

4.2 Two Approaches to Defining the Energy Problem

Over the past two decades, a debate has developed regarding how to define "the energy problem" (Brooks et al. 1983, 2-3, give a useful summary). The more conventional and older approach focusses on ensuring that adequate supplies exist to meet present and future energy demands. Analysis and policy are oriented around predicting most likely levels of future demand and establishing programs to ensure that sufficient supplies will be available when required.

The importance of estimating future energy needs is based on the long lead time required to design and construct major power generating facilities, such as thermal generating plants (coal, oil, nuclear) and hydro-electric facilities. If needs are underestimated, industrial and commercial activity will be suppressed; if needs are overestimated, expensive capital facilities will lie idle and serve to further drain the economy.

In the late 1970s and motivated by both environmental and economic concerns, a second approach emerged that identifies both demand and supply as policy-determined variables (SAB 1982, 27). In simple terms, this perspective recognizes that reduction of demand, as well as increasing supply, can satisfy the demand-supply balance.

In analysis, this second approach first emphasizes the consumption (demand) side of the equation rather than the production (supply) side of the equation. A detailed "bottom up" disaggregation of the end-use tasks that energy must perform is completed, then supply options are examined. As much consideration is given to the potential for reducing the level of energy end use as it is to supplying needs in the most appropriate manner.

An anticipatory stance is achieved, not by attempting to predict the future but by choosing desirable future characteristics (say, greater efficiency or less environmental stress) and "backcasting" to the present to design and choose a suite of actions required to achieve that future (Robinson 1982). Programs are aimed at reducing demand and matching end-use requirements to supply in an overall energy regime that is technically efficient, least cost, and imposes a minimum of stress on the ecosystem.

The energy supply mix that results is typically smaller scale, more decentralized, less technically complex, and more dependent on renewable forms of energy than those that result from the former analysis. As a result, this second kind of approach has come to be known as a "soft energy path analysis" (Lovins 1979) in contrast to the conventional approach that has led to the highly centralized, large-scale, complex, "hard" energy systems that have characterized the development of industrialized nations since World War II.

These two approaches reflect different sets of underlying values. The value base of the earlier supply-side approach is rooted in a kind of laissez-faire doctrine of consumer sovereignty (Brooks et al. 1983, 2; Brooks et al. 1981, Chapter 5). As a result, energy-related decision making is driven by the short-term economic implications of various supply options.

In contrast, a soft path analysis has at its foundation the very value set that underlies the concept of sustainability – a parallel concern and respect for the ecosystem and people within – not one or the other, not one more than the other, but both together.[2] As a result, in a soft path approach, decision making is driven by much broader technical, economic, social, and environmental implications of both energy end use and the various supply options. The insights offered by the soft path approach are used in this case study.

4.3 Energy Efficiency, Quantity, and Quality

Energy cascades from being a primary source (e.g., coal and peat, natural gas, crude oil, hydro potential, nuclear fuel, sunlight, wind, and biomass) to a secondary form (coal and peat, coke, coke oven gas, natural gas, refined petroleum products, active solar, biomass solids, methanol, vegetable oils, biogas, and electricity) to a tertiary form that provides the desired services such as motion, light, or heat. Brooks (1981, 271) points out:

> *. . . primary energy includes energy measured (by volume and by value) at the point of production whereas secondary energy includes energy measured at the point of consumption. . . . Secondary energy is always less than primary for three reasons: (1) the energy-supply industry consumes or loses energy in processing and transportation; (2) some primary energy is used to make petrochemicals and other non-energy products; and (3) roughly three units of fossil-fuel energy must be consumed to obtain one unit of thermally-generated electricity. . . . Ideally, in studying the use of energy, one would work with what could be called "tertiary" energy, i.e., the energy that actually does work for us by moving wheels, providing lights, or keeping us warm. Tertiary energy would be still smaller than secondary because of inefficiencies in the consuming system, and it would vary with the form in which the energy is supplied. (Gas furnaces, for example, tend to be more efficient in use than oil furnaces; electricity is most efficient for lighting.) However, except in a few cases, as with different systems for space heating, data are not available to permit analysis in terms of tertiary energy.*

At each transformation point from primary to secondary to tertiary, some amount of energy is given up to the transforming process and a lesser amount is thus subsequently available for doing work. The energy given up goes to heat, noise, light, or some other form that cannot be recaptured, but overall the amount of energy is always conserved. This principle of the conservation of energy is called the First Law of Thermodynamics.

The ratio of energy output to input through any process provides a measure of "First Law" efficiency. It is this measure of efficiency that is commonly understood when the issue of efficiency is addressed. From a societal perspective, the overall First Law efficiency of energy use depends on such factors as the nature of the processes that transform energy from primary source through secondary form to tertiary use, the effectiveness of transportation and transmission systems, and losses through accidents, spills, and poor insulation, (Torrie 1977, 6-11). Monitoring this First Law efficiency provides an important contribution to systematically assessing progress toward sustainability.

However, there is another aspect of efficiency that is not captured in the above. From the point of view of the energy user, a certain quantity of energy may be of differing value depending upon the amount of "useful work" that it can provide. For example, a unit of electricity can be used for many more things than a unit of energy produced by a living-room fireplace – even though the quantity of energy is the same in both cases. This difference is embodied in the concept of "energy quality," a measure of the amount of "useful work" that can be extracted from the total energy contained in that form (Brooks et al. 1983, 3; Brooks, 1981, Appendix A; Lovins 1979, Chapter 4).

The issue of energy quality is important because it introduces a notion of efficiency that is not captured in the First Law efficiency described previously. It recognizes that technical and economic efficiencies can be gained by matching end uses with an appropriate quality of energy. This aspect of efficiency has come to be known as "Second Law" efficiency because of its link to the Second Law of Thermodynamics. Formally stated, this law is:

> *A natural process that starts in one equilibrium state and ends in another will go in the direction that causes the entropy (or disorder) of the system plus environment to increase. (Modified from Halliday and Resnick 1966, 638-642)*

In rough terms and applied to energy production, it can be more simply expressed as "the quality of energy is always diminished (that is, becomes less valuable to us afterwards than it was before)" (Brooks 1981, 269).

The idea of calculating Second Law efficiency was first proposed in 1974 by the American Physical Society and the International Federation of Institutes of Advanced Study. They defined Second Law efficiency as the ratio of the least available work (energy) that could have done the job to the actual available work (energy) that was used to do the job (Torrie 1977, 6-12).

In principle, monitoring Second Law efficiency is as important to assessing progress toward sustainability as monitoring First Law efficiency. In reality, energy accounting systems are entirely geared to energy quantity and not quality. This is a serious limitation given that the largest gains in efficiency that remain are likely to be realized through (1) matching energy end uses to energy forms of appropriate quality; and (2) finding ways of doing things

Table 11
Energy end-use analysis categories

Residential
Single family detached
Single family attached
Apartments
Mobile homes
Hotels/motels/restaurants

Commercial
Offices
Schools/universities
Hospitals
Stores/shops
Hotels/motels/restaurants
Government street lighting

Industrial

Agriculture	Pulp and paper
Forestry	Iron and steel
Fishing, hunting, trapping	Smelting and refining
	Cement
Iron mines	Chemicals
Other mining	Other manufacturing
Food processing	Construction

Transportation

Air	Auto
Water	Truck
Rail	Bus

Source: Hodge and Ehrlich 1983, 4.

that create greater opportunities for being efficient (e.g., by prolonging the life of physical resources through improved materials use, increased product lifetimes, and recycling)[3] and from increasing the efficiency of providing real services, not just energy, to users (see discussion in Brooks 1981, 274-275).

The only comprehensive study that has addressed issues of both quantity and quality in Canada is summarized by Brooks et al. (1983). This work starts with a 1978 database and considers energy futures for the years 2000 and 2025. In their work, independent teams in each province and territory completed analyses that were then aggregated to national totals. Smith and Torrie provide a 1988 end-use analysis for Ontario at the sector level (1991, 7-18). No equivalent analysis has been completed for the United States as a whole or the eight Great Lakes states. In practice, no system exists that monitors Second Law efficiency throughout society.

4.4 The Starting Point: End-Use Analysis

Following the logic of the above discussion, the starting point for developing a system of monitoring and assessing energy production and use is appropriately a detailed end-use analysis that considers both energy quantity and quality. Each of the residential, commercial, industrial, and transportation sectors is initially considered separately and subsequently aggregated. Sectors are disaggregated in a way that is as consistent as possible with the Standard Industrial Classification. Table 11 lists a typical breakdown while Table 12 lists the four end-use categories that provide a rough link to energy quality. Table 13 provides the resulting end-use analysis for Ontario.

Table 11 demonstrates a critical link between this energy analysis and the Domain II analysis. The "standard activity classification" that builds on the Standard Industrial Classification provides a common organizational format. In this case, the "residential" sector has been added, which provides a natural link with the "household" estimate of value added listed in the Appendix 1 activity indicators. In addition, it is important in energy analysis to identify a "commercial" category, which is easily built from a number of elements of the Standard Industrial Classification.

Table 12
End-use categories that reflect energy quality

1. **Heating and cooling** (for warmth or comfort): mainly low-temperature heating and cooling of air and domestic hot water.
2. **Process heat**: heat used in industrial processes, either intermediate (100-260°C) or high (greater than 260°C).
3. **Liquid fuel**: land, sea, and air transport, as well as other activities requiring portable energy.
4. **Electricity specific**: lighting, communications, stationary motors, and other activities requiring clean, high quality, highly controllable energy.

Source: Bott et al. 1983, 45 and 53.

Table 13
Energy end uses in Ontario, 1978 (figures in petajoules)

	Coal & peat	Natural gas	RPPs	Electricity	Biomass solids	Biomass fluids	Active solar	Total
Residential								
Heating & cooling	—	183.90	172.00	50.60	5.00	—	—	411.50
Electricity specific	—	—	—	60.30	—	—	—	60.30
Total	—	183.90	172.00	110.90	5.00	—	—	471.80
Commercial								
Heating & cooling	—	130.10	69.37	2.27	—	—	—	201.74
Electricity specific	—	—	—	93.63	—	—	—	93.63
Total	—	130.10	69.37	95.90	—	—	—	295.37
Industrial								
Heating & cooling	—	22.40	—	—	—	—	—	22.40
Process heat-intermediate	—	181.00	48.80	—	—	—	—	229.80
Process heat-high	128.40	114.10	69.30	46.60	—	—	—	358.40
Electricity specific	—	—	—	74.40	—	—	—	74.40
Liquid fuel	—	—	44.40	—	—	—	—	44.40
Total	128.40	317.50	162.50	121.00	—	—	—	729.40
Transportation								
Electricity specific	—	—	—	0.70	—	—	—	0.70
Liquid fuel	—	—	587.00	—	—	—	—	587.00
Total	—	—	587.00	0.70	—	—	—	587.70
Totals								
Heating & cooling	—	336.40	241.37	52.87	5.00	—	—	635.64
Process heat-intermediate	—	181.00	48.80	—	—	—	—	229.80
Process heat-high	128.40	114.10	69.30	46.60	—	—	—	358.40
Electricity specific	—	—	—	229.03	—	—	—	229.03
Liquid fuel	—	—	631.40	—	—	—	—	631.40
Total	128.40	631.50	990.87	328.50	5.00	—	—	2084.27

Source: Torrie 1984, 44.

4.5 Balancing End-Use Requirements with Appropriate Secondary Forms and Primary Sources

In a comprehensive energy review, the end-use compilation is followed by a supply analysis that draws on estimates of current and future prices and the availability of a range of energy forms. Scale, proximity of source to use, and energy quality are all factors that are considered (Hodge and Ehrlich 1983, 4). Table 14 shows the production of primary sources and secondary forms for Ontario in 1978. It is the companion table to Table 13.

4.6 Proposed Indicators

Building on the preceding discussion, a list of indicators can be developed (and is presented

Table 14
Production of primary sources and secondary forms in Ontario, 1978 (figures in petajoules)

Primary Sources					Secondary Forms					
Source	**Production**	**Net inflow**	**Availability**	**Energy supply sector**	**Production**	**Net inflow**	**Energy supply sector**	**Non-energy use**	**Energy use**	**Form**
Coal & peat	—	478.20	15.40	—	15.40	—	—	—	15.40	Coal & peat
			142.80	12.20	130.60	(0.40)	—	60.30	69.90	Coke
			47.10	4.00	43.10	—	—	—	43.10	Coke oven gas
			272.90	175.70	97.20	*	*	*	*	Electricity
			—	—	—	—	—	—	*	Methanol
Natural gas	11.60	702.50	678.70	—	678.70	—	25.30	21.90	631.50	Natural gas
			35.40	19.60	15.80	*	*	*	*	Electricity
Crude	3.60	1,222.17	1,203.27	17.50	1,185.77	81.40	114.70	161.60	990.87	RPPs
			22.50	15.00	7.50	*	*	*	*	Electricity
Uranium	353.20	—	353.20	247.20	106.00	*	*	*	*	Electricity
Hydro	141.00	—	141.00	—	141.00	*	*	*	*	Electricity
Active solar	—	—	—	—	—	—	—	—	—	Active solar
			—	—	—	*	*	*	*	Electricity
Wind	—	—	—	—	—	*	*	*	*	Electricity
Biomass	5.00	—	5.00	—	5.00	—	—	—	5.00	Biomass solids
			—	—	—	—	—	—	—	Methanol
			—	—	—	—	—	—	—	Vegetable oil
			—	—	—	—	—	—	—	Biogas
			—	—	—	*	*	*	*	Electricity
					(367.50)	(2.40)	36.60	—	328.50	Total electricity
Total	514.40	2,402.87	2,917.27	491.20	2,426.07	78.60	176.60	243.80	2,084.27	Total

*All flows of secondary electricity are shown on the Total Electricity line.

Source: Torrie 1984, 45.

in Table 15) that would enable a given jurisdiction to monitor energy production, transportation, and use as part of assessing progress toward sustainability. The following list of indicators is modified from Marbek Resource Consultants (1990). Their work follows closely from the soft energy path analyses of the 1970s and 1980s, from which the above discussion was drawn. Energy produced and used for domestic purposes is addressed first. Eleven indicators are identified, grouped into five categories:

I. quantity and quality of energy produced, imported, and used;
II. efficiency of transformation and use;
III. imposed stress;
IV. longevity of energy supply; and
V. restoration.

A sixth category addresses energy for export and lists an additional five indicators. In each case, a specific objective is first articulated that reflects the three Domain II goals.

This approach to assessing energy production, transportation, and use is mapped on the assessment hierarchy shown in Figure 13. Like the assessment hierarchies offered in Section 3 (Figures 8, 9, 10, and 12), Figure 13 is intended as a template to guide assessment. Specific indicators would be chosen depending on local conditions.

4.7 Application in the Great Lakes Ecosystem

The only review of energy production, transportation, and use that synthesizes data from the eight Great Lakes states and Ontario in an effort to consider the Great Lakes ecosystem was completed by the Great Lakes Science Advisory Board (SAB 1982). Bournakis and Hartnett provide a more recent review dealing with energy in the eight Great Lakes states (1991). Their analysis draws heavily on indicators of:

- total and per capita energy use;
- total and per capita gross domestic and regional product;
- energy use per dollar of value added;
- energy supply by fuel type;
- net electrical energy use per person.

In their discussion, Bournakis and Hartnett (1991) use these indicators to address: (1) the increasing dependency of both the United States and the Great Lakes region on imported petroleum products; (2) the growing use of low-sulphur coal from outside the region to replace in-region high-sulphur reserves because of emission problems; and (3) the increasing pattern of electricity use per person and the implications of this growing demand for electricity on supply options (nuclear, coal, and natural gas). In passing, they raise a number of other energy-related issues including:

> *. . . alternative energy systems, solar and biomass (a major resource of the region); the future of regional transportation systems, including mass transportation, the railways, and the waterways; land-use planning and natural resources; automobile fuel economy standards, and priorities in energy research and development, to name a few. (Bournakis and Hartnett 1991, 84)*

The above list of issues and concerns demonstrates the potential breadth of energy as a topic of public policy. However, the aim of considering energy production and use as part of assessing progress toward sustainability is just that, to assess progress, not to address and resolve all current policy issues. As trite as this conclusion may seem, it is important for setting limits and maintaining a focus in the assessment process. The 16 proposed indicators listed in Table 15 are linked by the objectives of each category

Table 15
Energy indicator descriptions

I. Energy quantity and quality (domestic)

Objective: To reduce and minimize the quantity of energy produced, imported, and used for domestic purposes while maintaining or improving needed services.

Indicator 1. Secondary energy use by activity and quality
- quantity by activity, quality, and form: nation, province/state, region, and community, by subsector, sector, and total (gigajoules or equivalent per year).

Indicator 2. Proportion of end use met by imported energy
- nation, province/state, region, and community, by subsector, sector, and total (percentage).

Indicator 3. Secondary energy intensity
(energy use [gigajoules] per capita or some other variable such as passenger, floor area, or dollar of value added)

- nation, province/state, region, and community energy use per capita (gigajoules or equivalent per person);
- residential energy use per capita – total and by housing type (gigajoules per person);
- passenger transportation energy use per capita – total and by mode (gigajoules per person);[4]
- freight transportation energy use per tonne-kilometre of freight – total and by mode (gigajoules per tonne-kilometre);
- commercial energy use per area of floor space – total and by subsector (gigajoules per square metre of floor space);
- industrial energy use per dollar of value added – total and by subsector (gigajoules per dollar of value added).

II. Energy efficiency

Objective: To increase and maximize both the First Law and Second Law efficiencies of transformation from primary sources to secondary forms and tertiary services.

Indicator 4. *First Law efficiency*
- nation, province/state, or regional secondary/primary ratio (dimensionless ratio or expressed as percentage), total and by primary energy source.

Note: if data on tertiary energy use were available, a better indicator would be the tertiary/primary ratio.

Table 15 – cont.

II. Energy efficiency – cont.

Indicator 5. Second Law efficiency

- nation, province/state, or regional ratio of the least available work (energy) that theoretically could provide the required services to the actual available work (energy) that was used to provide the required services (dimensionless ratio or expressed as percentage) – by subsector, sector, and total.

III. Imposed stress

Objective: To reduce and minimize the total and per-unit-of-energy imposed physical, chemical, and biological stress on the ecosystem.

Indicator 6. Imposed physical stress

(as a result of energy production and transportation – nation, province/state, region, community)

- land area affected[5] – total and per unit of energy (hectares per gigajoule);
- noise levels generated – total and per unit of energy (appropriate units);
- heat discharged – total and per unit of energy (appropriate units);
- solid waste generated – total and per unit of energy (appropriate units).

Indicator 7. Imposed chemical stress

(as a result of energy production and transportation – nation, province/state, region, community)

- emissions of common and toxic contaminants to air, surface water, groundwater, and land; total and per unit of energy by contaminant species (tonnes per year and per gigajoule); subsector, sector, and total (could be grouped by issues of concern such as greenhouse gases, contributors to acid deposition, and artificial estrogens).

Indicator 8. Imposed biological stress

(as a result of energy production and transportation – nation, province/state, region, community)

- area of habitat degraded or lost (hectares);
- migration routes blocked or disrupted (streams or rivers blocked; hectares disrupted);
- introduction of exotic species (numbers of species introduced).

IV. Longevity of domestic energy supply

Objective: To ensure longevity of energy supply for domestic purposes.

Indicator 9. Primary energy supply by source

- annual primary energy supply by source – nation, province/state, region, community, sector, subsector (gigajoules per year and percentage of total).

Table 15 – cont.

IV. Longevity of domestic energy supply – cont.

Indicator 10. Proportion of domestic energy use met by abundant resources

- proportion of resources that are renewable or have reserves adequate to meet current levels of Canadian use for more than (say) 50 years[6] – nation, province/state, region, community, sector, subsector (percentage).

V. Restoration

Objective: To ensure restoration efforts are part of all energy-production activities.

Indicator 11. Restoration interest

- proportion of energy-producing facilities that include restoration as an explicit element of their corporate management strategy (percentage).[7]

VI. Exports

Objectives:

1. Following provision of domestic needs in both the short and long term, to generate foreign earnings from the export of energy resources for the benefit of Canadians and investors.
2. To do the above in a way that increases or maximizes both the First Law and Second Law efficiencies of transformation from primary sources to secondary forms and tertiary services.
3. To reduce and minimize the total and per-unit-of-energy imposed physical, chemical, and biological stress on the ecosystem.

Indicator 12. Net energy exports

- quantity of net energy exports (gigajoules) – nation, province/state, region by energy source; value of net energy exports (dollars) – nation, province/state, region by energy source.[8]

Indicators 13, 14, and 15. Imposed stress

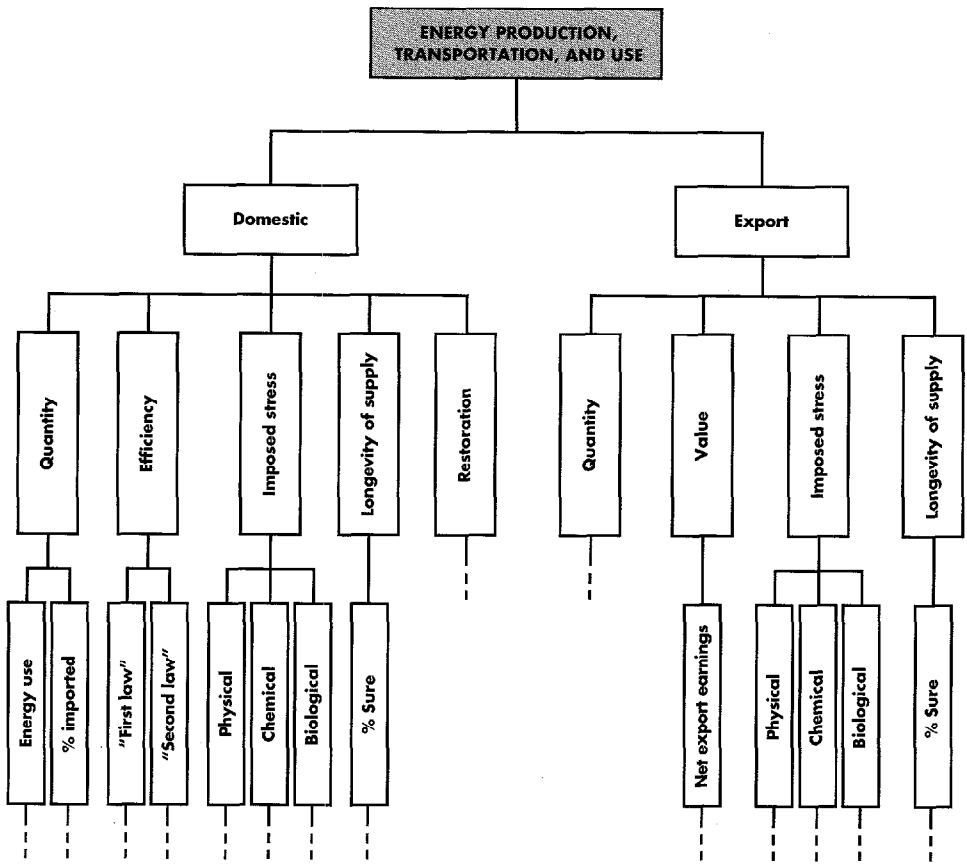
(total and per unit of energy produced or used [exported])

- physical: see indicator 6;
- chemical: see indicator 7;
- biological: see indicator 8.

Indicator 16. Proportion of energy exports met by abundant resources

- proportion of exports that are renewable or have abundant reserves – reserves adequate to meet, say, combined domestic and export demands over the next 50 years.

Figure 13
Assessment hierarchy for energy production, transportation, and use



Source: Hodge 1995.

to the goals of sustainability and provide the necessary input for making an initial assessment. Obviously, for any given policy issue, a much expanded set of indicators could be brought to bear.

A compilation that addresses the complete range of topics covered by the 16 proposed indicators has never been attempted. Current practice is reflected in the work of Bournakis and Hartnett and a review of their work in light of the proposed indicators leads to a number of observations and conclusions.

First, the dominant emphasis of current practice is on energy quantity, covered within Category I of the proposed indicators. Second, while time-series data on the proportion of energy imports are not presented graphically, Bournakis and Hartnett deal with the issue

extensively in their text. The region continues to depend on imported natural gas, petroleum, and coal, a dependence that is of significant concern for policymakers.

These indicators of the quantity of energy used provide a useful first step in assessing energy production, transportation, and use. However, they do not address energy quality or, directly, the efficiency of energy use (Category II). Instead, the reduction in total energy use per dollar of value added is used to imply improvements in the efficiency of industrial energy use. This may or may not be a fair conclusion.

While many industries undertook energy retrofits in response to the 1973 Arab oil embargo and the 1979 Iranian revolution, other factors changed as well. In particular, this same period has seen a significant restructuring of the economy with a shift away from many of the energy-intensive heavy industries to services (Allardice and Testa 1991, 12). This shift is as significant to the reduction in energy use per dollar of value added as the introduction of energy-efficient processes.

The power of using energy intensities, such as energy used per dollar of value added, is more apparent at the subsector level than in the aggregated form. Goldemberg et al. use this approach to facilitate a comparison of the energy intensity achieved in different manufacturing activities in Sweden and the United States (1987, 45-46). For example, in 1978, the chemicals industry in the United States used 195 megajoules per dollar of value added (1972$), while the Swedish chemicals industry used 45. Even at this level, care must be taken to consider the nature of the industrial activities themselves to ensure they are comparable before drawing conclusions. To bring surety, a greater degree of internal stratification in data must be considered than is apparent from the term "chemical industries."

In any case, energy intensity remains only an indirect measurement of efficiency of end use. Direct monitoring is both preferable and entirely possible. Data are available to calculate First Law efficiencies (Indicator 4) but not for calculating Second Law efficiencies (Indicator 5). This issue should be a high priority for those concerned with assessing progress toward sustainability.

Category III indicators (imposed stress) are not covered at all by Bournakis and Hartnett, although they make reference to a number of environmental concerns including the generation of urban smog, emissions contributing to acid deposition and global warming, toxic waste generation, and the implications of nuclear accidents (1991). A more extensive review of the environmental implications of energy production and use is provided by the Science Advisory Board (SAB 1982, 20-26). However, neither deal with the issue in any systematic way.

For its part, the Science Advisory Board recognized this deficiency and, in particular, voiced concern "that no mechanism presently exists to anticipate problems in the Great Lakes basin ecosystem which may arise from (human) activities" (SAB 1982, 149). It suggested development of a computerized system that models the relationship between human activities and the generation of pollution. This at least would deal with chemical stress. While there has been periodic interest in such an initiative (e.g., see Hoffman and McInnis 1988; Robert Associates 1991), no consistent support has been forthcoming from any level of government in either the United States or Canada. On the other hand, development of the Toxics Release Inventory (TRI) in the United States (starting in 1987) and the National Pollutant Release Inventory (NPRI) in Canada (starting in 1994) is generating

the kind of data required to make ongoing monitoring of chemical stress a possibility.

Energy supply (Category IV indicators) is dealt with in terms of relative energy share by fuel type. These data provide a perspective that is similar to that of Indicator 9 (primary energy supply by source), but the next step to development of an indicator that addresses the sustainability of supply (e.g., Indicator 10, proportion of domestic energy use met by abundant resources) has not been taken.

Bournakis and Hartnett also use figures for electrical energy use per person in their discussion of the growing need for a supply of electrical energy. These figures, too, should be used with great caution. The per capita indexing has the effect of hiding the exact source of the increase, since not everyone will have used the same growing amount of electricity in the 20-year period covered in the time series. If the increase were due to structural change in the economy, one might draw a different conclusion from these figures than if the increase were due to a conscious effort to reduce dependency on imported petroleum products. A finer degree of disaggregation is required than is apparent from the data that are presented.

The issue of restoration (Category V) is not a subject that has been included in energy analyses to date.

4.8 Assessment of Energy Production, Transportation, and Use in the Great Lakes Basin Ecosystem

Available data show a recent reduction in energy use per dollar of value added. However, how much of this change is due to structural adjustment in the economy and how much is due to improved energy efficiency is unknown. Since 1985, energy use per capita appears to be increasing after dropping in the late 1970s and early 1980s. There is also a continuing vulnerability because of dependency on imported petroleum products and coal. Based on these three observations alone, a weak conclusion can be drawn that current trends do not signal overall progress toward sustainability.

However, in addition to the above assessment, two important conclusions can be drawn. First, the current practice of energy analysis and energy-related data compilation in the Great Lakes (and elsewhere for that matter) is seriously deficient for effectively assessing progress toward sustainability. Only a minority of the indicators (1, 2, 3, and 7: per capita and total energy use, and some emissions data) are readily available in time-series form. Indicators dealing with energy quality, efficiency, imposed stress, the longevity of supply, and restoration (4, 5, 6, 8, 9, 10, and 11) are not readily available, although there is no technical reason to prevent their compilation. This situation is particularly alarming given the importance of energy to the sustainability equation (WCED 1987, Chapter 7, among many others).

Second, while it has not been possible within the limits of this study, to assess a broad number of human activities in a manner similar to the analysis of energy indicators, indicators related to other activities are likely limited in the same way as those for energy. Unfortunately, these are the data – on an activity-by-activity basis – that can help focus action where it is required. Until the kinds of indicators suggested in this case study are being compiled and monitored on a systematic and consistent basis, solution building will continue to be ad hoc and reactive to crises. Development and compilation of these indicators on an activity-by-activity basis must therefore be considered a high-priority research and development topic.

Endnotes – Section 4

1. In its discussion of energy and sustainability, the Brundtland Commission identifies four "key elements" that require reconciliation. These elements are better seen as specific objectives that can be associated with the generic Domain II goals as follows:

   a) To maintain or increase human well-being:

   - by ensuring the growth of energy supplies to meet human needs;
   - by the maintenance of public health, recognizing the potential health risks inherent in energy sources;

   b) To reduce stress on the environment:

   - by minimizing waste of primary resources through increased energy efficiency and conservation measures;
   - by ensuring overall protection of the biosphere and prevention of more localized forms of pollution (modified from WCED 1987, 169).

   The Brundtland Commission does not deal with the complete range of physical, chemical, and biological stresses nor does it deal with restoration activities as an aspect of its energy discussion.

2. The Brundtland Commission points out:

   Energy is not so much a single product as a mix of products and services, a mix upon which the welfare of individuals, the sustainable development of nations, and the life-supporting capabilities of the global ecosystem depend. In the past, this mix has been allowed to flow together haphazardly, the proportions dictated by short-term pressures on and short-term goals of governments, institutions, and companies. Energy is too important for its development to continue in such a random manner. A safe, environmentally sound, and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative. (WCED 1987, 202)

3. The use of scrap iron and steel instead of virgin material results in a 74 percent saving in energy; every tonne of glass recycled reduces the equivalent of 1,057 kilograms of carbon dioxide emissions; use of secondary paper resources instead of virgin materials results in a 74 percent reduction in air pollution, a 35 percent reduction in water pollution, and a 58 percent reduction in water use; for every tonne of paper recycled, the equivalent of three barrels of oil are saved in energy use (Environment Canada 1994, 4).

4. Energy use per capita was chosen over energy use per passenger-kilometre because there is less opportunity for misinterpretation. Changes in passenger-kilometre can be influenced as much by changes in technical efficiency of the system as by changes in ridership (Marbek 1990, 7). There is an analogy here with changes in energy use per dollar of value added. Changes in this indicator can be generated by economic structural changes as much as by true improvements in the efficiency of energy use. Provided it is known that the macroeconomic structure has been held constant, changes to energy use per dollar of value added can be used as an indicator of changes in the efficiency of energy use. However, this is usually not the case. Both of these examples serve to highlight the limitations of using energy intensities.

5. Marbek Resource Consultants suggest that a weighting scale be developed that captures the degree of imposed stress (and resulting degradation) and the sensitivity of the land where the stress is being imposed (1990, 9).

6. The 50-year time horizon is an arbitrary choice. Analysis may reveal that another figure is more appropriate. This is a topic for follow-up research.

7. This indicator is primitive. As restorative actions become more prominent, no doubt others will emerge to replace this one. At this stage the recognition that each facility has some responsibility for ecosystem restoration is what is most important.

8. Energy export is a delicate public policy issue. Presumably it is undertaken to generate financial benefits for Canadians. On this basis, and assuming Canadian ownership of resources (which is not always the case), the higher the "value" of energy exports, the higher the financial benefits that can accrue to Canadians. As in other assessments of activities, though, the assessment of value must be balanced against true full costs to Canada, including those carried by people and the ecosystem. In addition, full-cost analysis of energy exports should include assessment of human and ecosystem implications to the recipient jurisdiction.

5. Surface and Groundwater in the Great Lakes Ecosystem

5.1 Introduction

Water is a fundamental prerequisite for all life on earth. It is a critical ecosystem component and falls within the Domain I indicator hierarchy (see Figure 8). The Domain I goal, restated in terms of water, is "to maintain or improve the health and integrity of the water subsystem."

In this case study, the focus is on the water and not on the biota that the water supports – the water subsystem, not the aquatic ecosystem. The abiotic water subsystem is a self-organizing entity, driven by gravity and the many factors controlling the hydrologic cycle. Even so, bioindicators must be used because they have a significant role to play in the assessment of the water subsystem.[1]

Organisms serve to integrate the effects of all imposed stress, through time, and spatially in a way that series of discrete physical and chemical measures cannot. Further, it may be possible to identify bioindicators that reflect an ecosystem's ability to self-regulate. Because ecosystems under stress often behave in a surprising and discontinuous way, such indicators are likely the key for understanding the effects of human-imposed stress (see discussion in Kay and Schneider, 1994). This issue is the subject of much current research and its resolution is well beyond the scope of this case study.

However, the discussion is important because it highlights the difficulty of identifying the best signals to measure and monitor. There is, of course, no simple or single answer. What is clear from this work is that monitoring of progress toward sustainability requires a mix of physical, chemical, and biological measures, and the best combination at any given time will depend on the specific objective being addressed in the assessment process as well as on ecosystem conditions.

For example, following the above line of thinking, bioindicators are obviously essential for assessing ecosystem health and integrity, including that of the water subsystem. But chemical and physical measures are equally important for monitoring imposed chemical and physical stress. An

assessment whose objective is to maintain or increase the health and integrity of the aquatic ecosystem will require a set of indicators that is different from that required by an assessment whose objective is to reduce and minimize imposed stress on the ecosystem. These sets of data and information are closely related, but they are different.

5.2 Water and the Hydrologic Cycle

From a global perspective, the hydrologic cycle includes the nine elements listed in Table 16. This table also lists the volume and proportion of water held in each element and provides an estimate of residence time. The global water balance is dominated by oceans and seas, which account for 94 percent of all water by volume. Of the remaining 6 percent, 2 percent is held in icecaps and glaciers. The remainder is almost entirely groundwater. If only the most "active" groundwater is considered (4 million cubic kilometres instead of 60 million cubic kilometres), the freshwater breakdown comes to: groundwater, 95 percent; lakes, swamps, reservoirs, and river channels, 3.5 percent; and soil moisture, 1.5 percent (Freeze and Cherry 1979, 5).

This quantitative perspective must be tempered by a sense of the residence time (and thus the response time) of each component, which ranges from a few weeks for river water, a few weeks to a year for soil moisture, several thousand years for oceans and seas, and from weeks to over 10,000 years for groundwater.

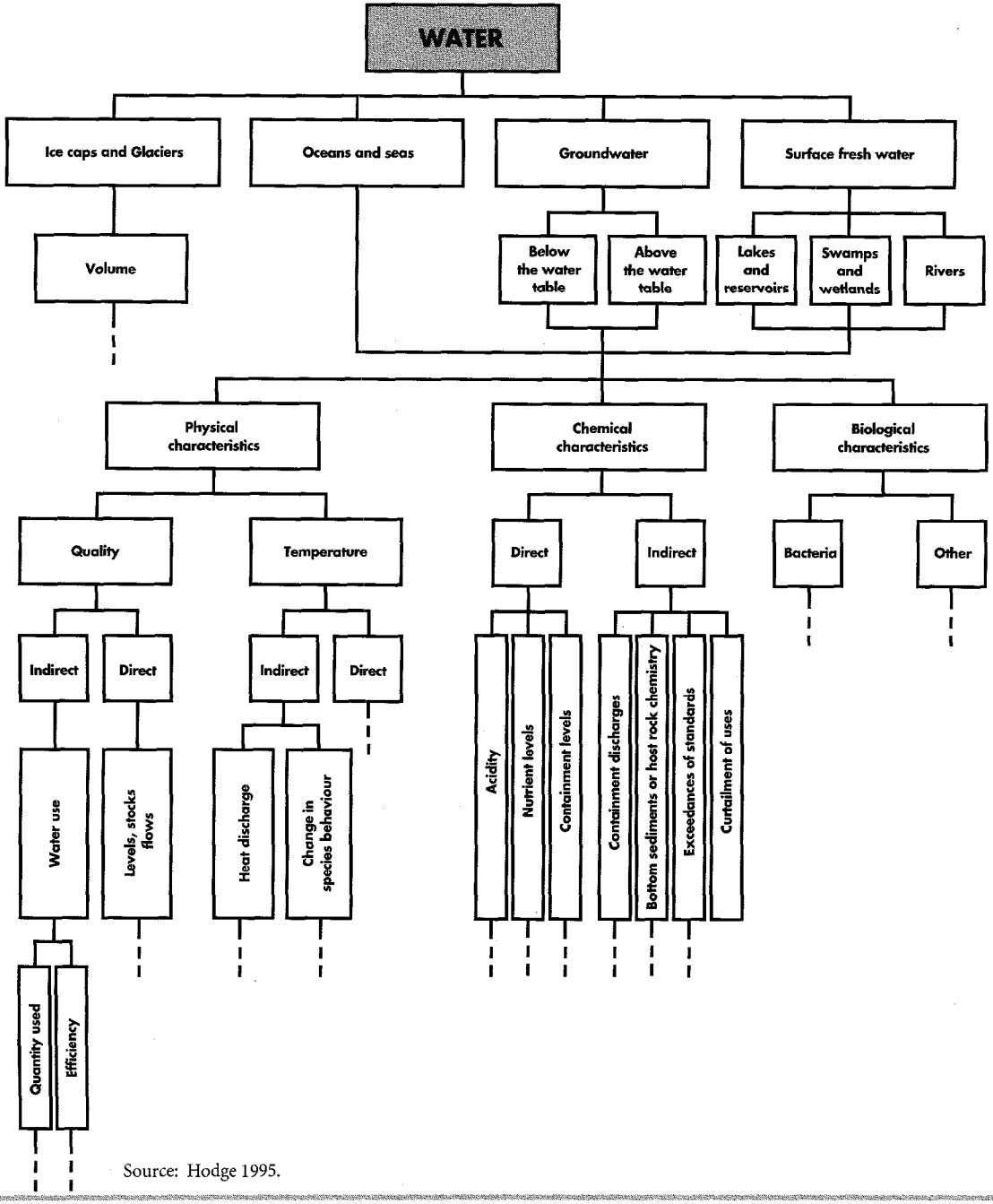
The above brief description helps in the identification of subsystem components that must be included in this assessment. Of the components listed in Table 16, atmospheric and biospheric water would be included in the air and climate designation of the Domain I assessment (see Figure 8) and soil moisture would be included as part of the unsaturated zone of the groundwater system.

Table 16
Components of the global hydrologic cycle with an approximate water balance

Component	Volume (million km³)	Proportion (percent)	Residence time
Oceans and seas	1,370.00	94.00	4,000 years
Groundwater	60.00	4.00	2 weeks - 50,000 years
Icecaps and glaciers	30.00	2.00	10 - 10,000 years
Surface freshwater:			
lakes and reservoirs	0.13	0.01	10 years
swamps and wetlands	0.01	0.01	1 - 10 years
river channels	0.01	0.01	2 weeks
Soil moisture	0.07	0.01	2 weeks - 1 year
Atmospheric water	0.01	0.01	10 days
Biospheric water	0.01	0.01	1 week

Source: Nace 1971; Chapman (ed.) 1992, 2.

Figure 14
Assessment hierarchy for the water subsystem



Source: Hodge 1995.

In conventional analysis, groundwater and surface water are typically described and assessed in terms of quantity and quality. In fact, there are physical, chemical, and biological characteristics that can help assess the state of each part of the water subsystem. Furthermore, there are direct and indirect indicators that can contribute to the assessment. These factors are all mapped out together on the assessment hierarchy shown below in Figure 14. The following section identifies specific indicators.

5.3 Proposed Indicators

As with energy, a set of indicators can be developed that would enable a jurisdiction to monitor the state of the water subsystem. Because the focus of this case study is on the Great Lakes basin ecosystem, two of the components of the water subsystem that are not directly relevant (ice caps and glaciers; oceans and seas) will be set aside and not further considered. What remains are the groundwater and surface water components. Within each are physical, chemical, and biological characteristics that can be used in an assessment of sustainability.

The state of groundwater or surface water is assessed by hydrogeologists, hydrologists, chemists, engineers, and others, who develop an understanding of the water subsystem using a variety of measures that depend on local conditions and data availability. For example, the hydrogeologist will study the local topography, physical and chemical characteristics of host media, precipitation, evaporation, evapotranspiration and groundwater recharge mechanisms as much as the groundwater itself. These kinds of factors determine the nature of the groundwater flow system. Understanding them is essential for estimating any change to the groundwater flow system that might result from, say, well withdrawals or contaminant discharges.

A hydrologist will be interested in precipitation, evaporation, evapotranspiration, stream gradients, channel characteristics, lake-water dynamics, and so forth, as well as in the chemistry, flow, and volume of surface water. These are the factors that determine the nature of the hydrologic system.

Altogether, the body of knowledge related to the water subsystem is vast and an enormous number of specific physical, chemical, and biological measures are gathered in support of the variety of interested disciplines.

The task here is to distill from this body of knowledge, certain key factors that signal the state of the system. This task must be undertaken with care, since, once the indicators are isolated from the larger body of knowledge, they can be easily taken out of context.

In practice, the choice of key indicators for monitoring and assessing the state of the water in any given ecosystem is best done following a comprehensive full-system assessment that provides an adequate foundation for that choice. This comprehensive assessment should be repeated periodically to allow for changing conditions.

Section 305b of the United States Clean Water Act requires the U.S. Environmental Protection Agency together with the states to prepare a nationwide inventory and assessment of water quality in all navigable waters. Reports must be filed every two years. These reports must:

> *. . . include an inventory of all point sources of discharge (based on a qualitative and quantitative analysis of discharges) of pollutants, into all navigable waters, and the waters of the contiguous zone; and*
> *. . . identify specifically those navigable waters, the quality of which:*

Table 17
Ohio's surface water use designations

Aquatic life uses
- warmwater habitat;
- exceptional warmwater habitat;
- coldwater habitat;
- seasonal salmonid habitat;
- limited resource water.

Water supply
- public water supply.

Recreation
- primary contact;
- secondary contact.

State resource waters
- state resource waters;
- outstanding resource waters.

Source: Rankin et al. 1990, 6.

Table 18
Current impairments of the Lake Ontario ecosystem

Aquatic biota
- degradation of fish, phytoplankton, and zooplankton populations;
- fish tumours or other deformities;
- degradation of benthos;
- loss of habitat;
- presence of exotic species;
- changes in indicators of chemical stress (biomarkers).

Wildlife dependent on aquatic biota
- degradation of bird and wildlife populations;
- bird or animal deformities or reproductive problems;
- loss of habitat;
- changes in indicators of chemical stress (biomarkers).

Human health
- restrictions on human consumption of fish and wildlife;
- restrictions on drinking water consumption, or taste and odour problems;
- beach closings;
- degradation of aesthetics;
- congenital abnormalities, reproductive, or developmental effects;
- psychosocial impacts.

Water quality
- eutrophication or undesirable algae;
- beach closings;
- elevated water-column contaminant concentrations.

Sediment quality
- degradation of benthos;
- restrictions on dredging activities;
- elevated sediment contaminant concentrations.

Source: Rang et al. 1992, 292.

1. *is adequate to provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allow for recreation activities in and on the water;*
2. *can reasonably be expected to attain such level by 1977 or 1983; and*
3. *can reasonably be expected to attain such level by any later date.*

The assessment criteria in (1.) above have come to be known as the "fishable and swimmable" use criteria of the Clean Water Act. In most states, however, these criteria serve as a starting point for an expanded set that serve local purposes. For example, Ohio has developed the use designations listed in Table 17. Using both chemical and biological criteria, navigable courses and bodies of water are classified on the basis of uses being: fully attained; fully attained but threatened; not attained; partially attained; or not assessed (see discussion in Rankin et al. 1990, 6-10).

Yet another application of the idea of water use impairment is found in the Great Lakes Water Quality Agreement, which lists 14 "impairments of beneficial uses" (see Table 9). These impairments provide the framework for establishing criteria for listing and delisting a given degraded area in the Great Lakes as an official "area of concern" (see GLWQB 1991b, 10-14).

In an interesting piece of work, Rang et al. assess the impairment of uses in Lake Ontario. They use the above list of 14 use impairments as the organizing framework for their study and, in the process, test the applicability of the list to the Lake Ontario aquatic ecosystem. In summary, they point out that the 14 use impairments in the Great Lakes Water Quality Agreement are really "routes by which contaminants may adversely affect ecosystem components" (Rang et al. 1992, 292). They suggest alternative assessment criteria that focus directly on ecosystem components. Their list, provided in Table 18, is consistent with Ohio's move to direct measures of the state of in-stream biological communities.

Water use is an indirect indicator for assessing the water subsystem, since it assumes a relationship between use and the actual state of the water subsystem. However, both direct and indirect indicators can be helpful in assessment and both have an important role to play in communicating conditions to decision makers. Further, water use is a direct indicator of human activity and provides a convenient linkage to Domain II analysis.

Table 19 identifies 23 water subsystem indicators organized in the following four categories:

I. groundwater – physical characteristics;
II. groundwater – chemical characteristics;
III. surface water – physical characteristics; and
IV. surface water – chemical and biological characteristics.

For each category, specific objectives are articulated that reflect the Domain I goal. A list of indicators then follows. These are intended as generic suggestions. In any given situation, local conditions might well lead to the choice of other specific indicators that are more useful for monitoring than those suggested here.

5.4 Application in the Great Lakes Ecosystem

A vast literature on the Great Lakes ecosystem's surface and groundwater has been generated since the signing of the Boundary Waters Treaty in 1909. The following discussion analyses the water subsystem from the perspective of sustainability. It also provides an assessment of the adequacy of the data and information base.

Table 19
Water indicator descriptions

I. Groundwater – physical characteristics

Objectives:

1. Quantity: To maintain the groundwater flow system such that any withdrawals are within the natural annual recharge.
2. Stress: To reduce and minimize the physical stress imposed on the groundwater flow system.
3. Use Efficiency: To increase and maximize the efficiency of water use.

Direct indicators

Indicator 1. Ratio of recharge to discharge
- direct measurement expressed as a dimensionless number or percentage;
- trends in the average annual position of the water table (elevation in metres or equivalent).

Indirect Indicators

Indicator 2. Groundwater withdrawals
- withdrawals (volume per unit of time): nation, province/state, region, and community by subsector, sector, and total.

Indicator 3. Efficiency of groundwater use
- ratio of the least necessary amount of groundwater required to provide a given service to the actual amount used (dimensionless ratio or expressed as percentage): nation, province/state, region, or community by subsector, sector, and total.

II. Groundwater – chemical characteristics

Objectives:

1. Quality: To maintain groundwater quality that is (a) within the range of natural ambient conditions for any given locale, or (b) characterized by elevated contaminant levels but only to a degree that can be attenuated by natural processes to "safe" levels (for any biota including humans) prior to discharge to wells, surface water, or vegetation.
2. Stress: To reduce and minimize the chemical stress imposed on the groundwater flow system.

Direct indicators

Indicator 4. Concentrations of contaminants
- concentrations of contaminants by chemical species (mass per unit of volume, e.g., milligrams per litre).

Table 19 – cont.

II. Groundwater – chemical characteristics – cont.

Indirect indicators

Indicator 5. Discharges of contaminants to groundwater

- discharges of contaminants by species (mass or volume per unit of time); nation, province/state, region, and community by subsector, sector, and total.

Indicator 6. Non-compliance with standards

- incidents of non-compliance per year related to contaminant discharges to groundwater (time exceeding standard combined with some assessment of seriousness of incident); nation, province/state, region, and community by subsector, sector, and total.

Indicator 7. Use curtailment

- incidents of use curtailment (e.g., wells abandoned) as a result of contamination of groundwater; nation, province/state, region, and community by subsector, sector, and total.

III. Surface water – physical characteristics

Objectives:

1. Quantity: To maintain surface water flows such that water level changes mirror natural seasonal changes in any given year and any withdrawals are within the natural annual recharge.
2. Temperature: To maintain surface water temperature such that any changes mirror natural seasonal changes and the range of any change is within the natural range.
3. Stress: To reduce and minimize the physical stress imposed on the surface water system.
4. Use Efficiency: To increase and maximize the efficiency of water use.

Direct indicators

Indicator 8. Flow rate or level

- direct measurement of flow (volume per unit of time) or level (height in metres above some datum).

Indicator 9. Temperature

- direct measurement of temperature (degrees Celsius).

Indicator 10. Water course continuity

- proportion of rivers and streams blocked by built infrastructure; water courses classified on the basis of their importance for human use and wildlife use.

Table 19 – cont.

III. Surface water – physical characteristics – cont.

Indirect indicators

Indicator 11. Surface water withdrawals including diversions
- withdrawals or diversions (volume per unit of time): nation, province/state, region, and community by subsector, sector, and total.

Indicator 12. Efficiency of surface water use
- ratio of the least necessary amount of surface water required to provide a given service to the actual amount used (dimensionless ratio or expressed as percentage): nation, province/state, region, and community by subsector, sector, and total.

IV. Surface water – chemical and biological characteristics

Objectives:

1. Quality: To maintain surface water quality that is within the range of natural ambient conditions for any given locale.
2. Stress: To reduce and minimize the chemical and biological stress imposed on surface water.

Direct indicators

Indicator 13. Contaminant levels
- concentrations of contaminants by chemical species (mass per unit of volume, e.g., milligrams per litre).

Indicator 14. Nutrient levels
- concentrations of nutrients (nitrate plus nitrite, phosphorus) (mass per unit of volume).

Indicator 15. Acidity
- pH measurement.

Indirect indicators

Indicator 16. Contaminant levels in biota
- concentrations of contaminants by chemical species in aquatic biota (e.g., fish flesh) and other biota that depend on aquatic organisms for their diet (e.g., fish-eating birds) (mass per unit of volume, e.g., milligrams per litre).

Indicator 17. Bottom sediment geochemistry
- contaminant content of bottom sediments (mass per unit of volume).

Table 19 – cont.

IV. Surface water – chemical and biological characteristics – cont.

Indicator 18. Discharges of contaminants to surface water
- discharges of contaminants by species (mass or volume per unit of time); nation, province/state, region, and community by subsector, sector, and total.

Indicator 19. Discharges of nutrients to surface water
- discharges of nutrients by species (mass or volume per unit of time); nation, province/state, region, and community by subsector, sector, and total.

Indicator 20. Non-compliance with standards
- incidents of non-compliance per year related to discharges of contaminants to surface water (time exceeding standard plus some measure of seriousness of incident); nation, province/state, region, and community by subsector, sector, and total.

Indicator 21. Use curtailment
- incidences of use curtailment (e.g., use by aquatic biota and use by humans, including drinking water limitations, beach closures, and fishing closures) as a result of contamination of surface water; nation, province/state, region, and community by subsector, sector, and total.

Indicator 22. Bacterial levels
- levels of bacteria (coliform count per unit of volume).

Indicator 23. Other bioindicators of the state of surface water
- species health (including human), population health, biodiversity, and so forth;
- biological indices, such as the Index of Biotic Integrity (IBI, based on fish), the Modified Index of well-being (Iwb, based on fish) and the Invertebrate Community Index (ICI, based on macroinvertebrates) (see endnote 1).

I. Groundwater – Physical Characteristics

An overview of the state of understanding of groundwater in the Great Lakes basin is provided by Hodge who points out that half the residents in the eight Great Lakes states and Ontario depend on groundwater for their primary water supply (1990, 449). Hodge also describes a number of areas within the Great Lakes basin where groundwater is being mined and the amount extracted is more than the natural system can replenish. The result is a permanent lowering of the water table. The most extreme example is the Chicago-Milwaukee area where the groundwater system has been subject to withdrawals since the late 1800s.

Continuous pumping since then has caused water levels in the Chicago area to drop, on average, 800 feet (244 metres). One quarter of the fall has occurred since 1971. Water levels in some Chicago area wells are now 100 to 150 feet (30 to 46 metres) below sea level. The growing cone of influence extends well beyond the boundaries of the Great Lakes hydrologic basin causing groundwater to flow northwest from Indiana,

west from Lake Michigan, and south from Wisconsin. The withdrawal of water from Lake Michigan through the groundwater system is substantial enough to be included in Illinois' allocation of Lake Michigan water.

Similar groundwater mining has been a concern, though not as extreme, in the Lake Winnebago area and in Green Bay, Wisconsin. It appears to be an emerging problem in some growing suburban residential areas in southern Ontario (Hodge 1990, 451-452).

The above kinds of data and information provide useful input for development of Indicator 1, ratio of recharge to discharge (Table 19). Similarly, Hodge provides a summary of groundwater annual withdrawals by state/province and use (municipal, rural domestic, agriculture, and industrial self-supply) that directly contributes to Indicator 2 (groundwater withdrawals). Trends in use over time are not available. No attempt has ever been made to quantify the efficiency of water use (groundwater or surface water) throughout the Great Lakes basin (Indicator 3), although residential, commercial, and industrial activities in most of North America are extremely inefficient in water use – largely because of the historical over-abundance of available water.

Overall, what little is known about the groundwater flow system suggests that in some areas, groundwater mining is seriously depleting the resource. However, the overall groundwater flow system in the Great Lakes basin is ill-understood, a surprising conclusion given the proportion of people dependent upon it for their primary water supply.

II. Groundwater – Chemical Characteristics

Hodge also reviews groundwater quality in the Great Lakes basin and relates a number of cases where degraded groundwater quality is a significant concern (1990, 452-462). For example, groundwater-borne contaminants from buried hazardous waste are likely the major single source of toxic contaminants to the Niagara River and Lake Ontario (458).

In 1975, the Great Lakes Basin Commission completed a review of groundwater in the eight Great Lakes states (GLBC 1975), and groundwater quality is reviewed as part of the biennial reports to the United States Congress by states under Section 305b of the Clean Water Act. In Ontario, no overview of groundwater quality has ever been completed.

In short, there is a serious lack of understanding of overall ambient groundwater quality in the Great Lakes basin that matches the lack of understanding of the physical groundwater flow regime. Concern caused by this conclusion led the Great Lakes Science Advisory Board to address groundwater contamination in their 1991 report to the International Joint Commission:

> *It has been ten years since the Commission alerted the Governments to the serious problem of toxic and hazardous substances in the Niagara River and the threat posed by contaminated groundwater from abandoned or improperly-operated hazardous waste facilities being released into the river. It has been eight years since the Science Advisory Board recommended increased attention to groundwater contamination and escalated the mapping of contaminants so that policy decisions on cleanup progress could be based on facts. These recommendations have not been implemented and the public remains in the dark on the basin-wide significance and ramifications of groundwater contamination. (SAB 1991, 57)*

What is known is that localized groundwater problems are becoming more common because of the large variety of contaminant sources.

Table 20 lists the dominant sources of groundwater contamination in the eight Great Lakes states and Ontario.

While it has been possible to compile this list of contaminant sources, a numerical estimate of actual discharges over time from various sources is not currently possible (Table 19, Indicator 5). Since 1987, the U.S. Toxics Release Inventory has been compiling statistics on discharges to groundwater from a range of manufacturing facilities. Thus a start has been made.

An overall compilation of the exceeding of standards (Table 19, Indicator 6) and use curtailments (Indicator 7) has never been attempted. Data and information are available but lie scattered among many local sources.

Programs to control existing discharges of contaminants to groundwater and prevent new ones are in their infancy, and it is likely that discharges of contaminants to groundwater are increasing, while overall groundwater quality is likely deteriorating.

III. Surface Water – Physical Characteristics

Of the five indicators listed in Table 19 for describing physical characteristics of surface water, Indicator 8 (flow rate or levels), and Indicator 10 (surface water withdrawals including diversions) are likely supported by the largest database of all the 23 listed indicators. In the Great Lakes proper, both topics have been the subject of formal assessments by the International Joint Commission (IJC 1985; Levels Reference Study Board 1993). Resolution of disputes regarding the use of boundary waters for navigation, power, and industrial use was the primary motivation for the 1909 Boundary Waters Treaty that led to the creation of the International Joint Commission in the first place.

While the priority surface water focus within the Great Lakes basin ecosystem has been on the Great Lakes and their connecting channels, over 80,000 inland lakes and 750,000 kilometres (466,000 miles) of upland rivers and streams are also part of the ecosystem (Colborn et al. 1990, 85). Even here, a significant amount of data is available describing flows, levels, and withdrawals. The motivation for this database lies in the desire to use water for power and irrigation as well as for domestic, industrial, and municipal water supplies.

Water quantity has not generally been perceived as a problem in the Great Lakes basin ecosystem, although both extreme high and low water levels on the Great Lakes proper and their connecting channels have led to "crises" from time to time. Further, there is ongoing debate about the implications of diverting water out of the Great Lakes system to address water shortages elsewhere in the United States (see IJC 1985 and Day and Quinn 1992 for useful discussions).

In the upland rivers and streams, dam construction has led to significant changes to the surface water system. These, in turn, have led to the impairment of fish migration routes, spawning grounds, and overall aquatic habitat. Indicator 10 addresses water course continuity linked to an assessment of the importance of water courses for humans and for fish and wildlife. While some dam inventories are available, no overall count and assessment of river and stream channel blockages in the Great Lakes basin ecosystem has ever been completed.

IV. Surface Water – Chemical and Biological Characteristics

Of the 11 indicators listed in Table 19 for describing chemical and biological characteristics, all but Indicator 20 (compliance with standards) have been used in the telling of the Great

Table 20
Dominant sources of groundwater contamination in the eight Great Lakes states and Ontario

(Bracketed figures indicate the percentage of the population dependent on groundwater for their primary water supply.)

Pennsylvania (90%)
- acid mine drainage;
- underground storage tanks;
- surface impoundments (excluding oil and gas brine pits);
- on-site industrial landfills;
- septic tanks;
- abandoned hazardous waste sites;
- other: oil and gas brine pits, road salt, agricultural activities, land application of sewer sludge.

Minnesota (75%)
- industrial/manufacturing (on-site spills, illegal or uncontrolled disposal, industrial impoundments);
- solid-waste landfills and dumps;
- storage and transportation of petroleum and other products;
- agricultural activities;
- municipal impoundments and land treatment facilities;
- individual septic system;
- road salt, salt storage.

Wisconsin (67%)
- agricultural activities;
- solid-waste landfills;
- abandoned waste sites;
- underground storage tanks;
- spill incidents.

Indiana (59%)
- handling, storage, spillage, and eventual disposal of hazardous waste;
- mining;
- production of brines associated with oil and gas drilling;
- agricultural activities;
- underground storage tanks.

Michigan (51%)
- petroleum-related;
- unknown;
- landfill;
- miscellaneous industrial products;
- metal plating and production;
- chemical production and manufacturing;
- salt storage;
- agriculture- and food-related;
- laundromats;
- hazardous waste handling.

Ohio (50%)
- hazardous waste;
- solid waste;
- leaks and spills;
- agriculture;
- household wastewater systems, especially septic tanks;
- mining, oil and gas extraction and associated waste disposal;
- improperly constructed and maintained water wells;
- road salt.

Illinois (48%)
- underground storage tanks;
- abandoned hazardous waste sites;
- municipal and industrial landfills;
- agricultural activities;

Table 20 – cont.

- production of brines associated with oil drilling;
- industrial activity (solvents, plating, metal finishing);
- road salt;
- coal mining and oil production;
- materials storage.

New York (35%)
- underground storage tanks;
- hazardous materials, leaks, and spills;
- abandoned hazardous waste sites;
- municipal and industrial wastewater treatment plant effluent and small leaks and spills associated with facility housekeeping;
- municipal landfills;
- agricultural activities;
- uncovered road salt piles.

Ontario (23%)
- improper construction of well and septic systems;
- road salt;
- gasoline or heating oil storage tanks;
- industrial leaks and spills;
- improper storage in waste disposal sites, particularly in older sites;
- abandoned coal-gassification plants;
- deep well disposal;
- agricultural activities;
- storage and disposal of radioactive waste;
- mine tailings.

Source: Hodge 1990, 449 and 460-462.

Lakes story at the beginning of this case study. Data describing the attainment of standards are also available from both government and industry sources but have not been compiled for the Great Lakes basin ecosystem as a whole. Since the 1960s, the issue of Great Lakes water quality has been the dominant concern for residents of the Great Lakes basin ecosystem and it is not surprising that the database is extensive.

5.5 Assessment of the Water Subsystem in the Great Lakes Basin Ecosystem

Groundwater

Roughly half the residents of the eight Great Lakes states and Ontario depend on groundwater for their primary water supply, and yet groundwater flow systems and chemistry have not received extensive study and, as a result, are ill-understood. No overall assessment has ever been completed although some local data are available related to indicators 1, 2, 4, and 5. No compilation of indicators 3, 6, and 7 has ever been attempted.

A number of major cases of unsustainable groundwater use are documented, the most extreme example of which is in the Chicago-Milwaukee area. Programs to control existing discharges of contaminants to groundwater and prevent new ones are in their infancy and it is likely that discharges of contaminants to groundwater are increasing. With this increase, it is likely that overall groundwater quality is deteriorating. Overall, the groundwater component of the water subsystem is

likely not following quantity or quality trends that are consistent with sustainability.

Surface Water

In contrast to groundwater, surface water may be the best understood component of the Great Lakes ecosystem. Of the 16 indicators listed, only one direct indicator (Indicator 10, water course continuity) and three indirect indicators (Indicator 12, efficiency of use; 20, compliance with standards; and 21, use curtailment) are not readily available on a time-series basis.

In summary, data and information are available to support the following conclusions regarding surface water in the Great Lakes basin ecosystem:

Physical characteristics

(Direct Indicators)

- Indicator 8: water flows maintain a rhythm and variation that mirror natural conditions;
- Indicator 9: with local exceptions adjacent to industrial and municipal facilities, water temperatures are within natural ranges;
- Indicator 10: while no comprehensive inventory has been compiled, the continuity of many inland rivers and streams is broken by built infrastructure. The complete range of ecosystem implications has not been established, nor has there been any attempt to balance these implications against the benefits achieved in terms of water supply, irrigation, power, and so forth;

(Indirect Indicators)

- Indicator 11: withdrawals and diversions are generally within the natural annual recharge;
- Indicator 12: the efficiency of surface water use is far lower than is technically and economically possible;

Chemical and biological characteristics

(Direct Indicators)

- Indicator 13: concentrations of most common and toxic contaminants in surface water have shown a significant improvement over the past 15 years; concentrations at dozens of local areas remain elevated to the point of impairing some uses by humans and wildlife; although concentrations of some persistent toxic substances meet ambient water quality standards, the processes of bioaccumulation and biomagnification mean that concentrations (although below water quality standards) are still high enough to cause injury to fish, wildlife, and humans;
- Indicator 14: excess nutrient problems due to phosphorus in the Great Lakes proper have been greatly reduced, although trophic conditions are still not at targeted levels in some areas (e.g., the bottom waters of Lake Erie). Eutrophication remains a significant problem in a number of nearshore areas and inland lakes. Increasing nitrate-plus-nitrite concentrations throughout the Great Lakes have been documented since the turn of the century and remain a concern, particularly in terms of their potential impact on the lower trophic levels of the food web;
- Indicator 15: acidification remains a serious problem in many inland lakes;

(Indirect Indicators)

- Indicator 16: body burdens of persistent toxic substances in fish and wildlife have shown significant improvements since the early 1970s. However, since the late 1980s, trends have been inconsistent and a number of contaminants have shown either little further change or increasing levels. For many substances, levels remain above

objectives specified in the Great Lakes Water Quality Agreement or other guidelines and standards. Restrictions on fish consumption exist in certain areas around the lakes. Continued high levels of substances whose use has been restricted signal (1) re-release of contaminants previously deposited in the ecosystem, (2) continued release from improper storage of waste and remaining stocks, or (3) continuing use in remote areas and subsequent transport into the basin;

- Indicator 17: contaminated lake or river bottom sediments remain a serious problem in 42 of the 43 "areas of concern." In general, recently deposited sediments are less contaminant-laden and, by capping earlier deposits, are contributing to an improvement. However, at this stage, contaminated bottom sediments are a continuing source of contaminants and nutrients to the water column, particularly in areas where storm action re-suspends bottom sediments;
- Indicator 18: many industrial and municipal point-source discharges of contaminants have achieved reductions over the past 20 years. However, the cumulative discharge from point sources in the Great Lakes system remains a serious concern. Urban and rural non-point sources as well as accidental discharges continue to be a significant concern;
- Indicator 19: phosphorus loadings from municipal and industrial point sources have been significantly reduced since the signing of the original Great Lakes Water Quality Agreement in 1972. Most (but not all) point sources are now meeting the targeted levels. Rural non-point sources, particularly from agricultural runoff, remain a serious problem;
- Indicator 20: the majority of municipal and industrial facilities are in compliance with point-source discharge regulations for nutrients and contaminants. The significance of discharges that are not in compliance for any given year has not been assessed;
- Indicator 21: an overall assessment of surface water use curtailments for any given year has not been completed;
- Indicator 22: elevated bacteria levels are no longer as serious a problem as they were 20 years ago. However, they remain a significant concern for some nearshore and inland areas and from time to time lead to restrictions in use.
- Indicator 23: the population health status of fish, water-dependent wildlife, and aquatic vegetation is variable: some species are recovering, while some key species such as lake trout and eagles are still unable to establish self-sustaining populations. Biota remain threatened in acidifying inland lakes. Many populations are not well monitored and an overall assessment of the population health status of fish, water-dependent wildlife, and aquatic vegetation has not been completed. There is growing concern that human health remains threatened.

The above summary is drawn from many sources including Colborn et al. 1990; Canada 1991; Environment Canada et al. 1991; GLWQB 1989, 1991a, 1991b, and 1993; SAB 1991; Virtual Elimination Task Force 1993; IJC 1982, 1984, 1986, 1989, 1990, 1992, and 1994; and The Nature Conservancy 1994. While the 16 indicators addressing surface water (Indicators 8 to 23) signal some improvements, there are at least 10 indicators of ongoing concern:

- Indicator 10: lack of continuity of inland rivers and streams;
- Indicator 12: low efficiency of water use;
- Indicator 13: elevated contaminant levels in local areas;
- Indicator 14: eutrophication in a number of nearshore areas and inland lakes, increasing nitrate-plus-nitrite levels throughout the Great Lakes basin;
- Indicator 15: ongoing acidification in inland lakes;
- Indicator 16: a stabilizing or even increasing trend in the body burdens of some persistent toxic contaminants;
- Indicator 17: contaminated bottom sediments in "areas of concern";
- Indicator 18: cumulative discharge of contaminants from point sources and ongoing discharges from urban and rural non-point sources;
- Indicator 19: rural non-point sources of nutrients; and
- Indicator 23: ongoing population health problems for a range of fish and water-dependent wildlife; growing concern that human health remains threatened.

Summary

In spite of the documented improvements in a number of factors, the number and seriousness of the remaining concerns, combined with the conclusions reached regarding groundwater, suggest that the water subsystem of the Great Lakes basin ecosystem is not yet on a path toward sustainability.

Endnotes – Section 5

1. Throughout the last decade there has been an active debate about the relative merits of measures of water column chemistry as opposed to direct measures of the state of in-stream biological communities for assessing use impairments, particularly use as aquatic habitat.

Rankin and Yoder point out that, historically, reliance on chemical-specific criteria has come about because:

- past efforts in water pollution control have focussed, almost exclusively, on point sources of pollution (municipal wastewater treatment plants and industry), where ambient chemical criteria are translated directly to discharge limits;
- analytical and field survey techniques for biological community data were not well refined;
- a working definition of "biological integrity" was not forthcoming;
- biosurvey data had an unfortunate reputation for being too expensive, variable, or imprecise; and
- chemical methods were thought to be more "precise" than biological assessments (1990, I-2).

However, reliance on chemical monitoring alone may overlook the fact that:

- pollution is often episodic and might be missed by typical monitoring programs;
- some chemical parameters that cause degradation may not be measured or easily identified; and
- degradation of stream resources may also be caused by non-point pollution and habitat destruction, variables that most chemical monitoring programs cannot easily consider (Rankin et al. 1990, 4).

In Ohio, between 1986 and 1988, assessment based on chemical surrogates and biological narrative descriptions was replaced by one based on ecoregion-based biological criteria integrated with various chemical and physical data (Rankin and Yoder, 1990). As a result, the proportion of Ohio's rivers and streams attaining aquatic uses dropped from 61 percent to 25 percent of those monitored. Subsequent analysis suggested that:

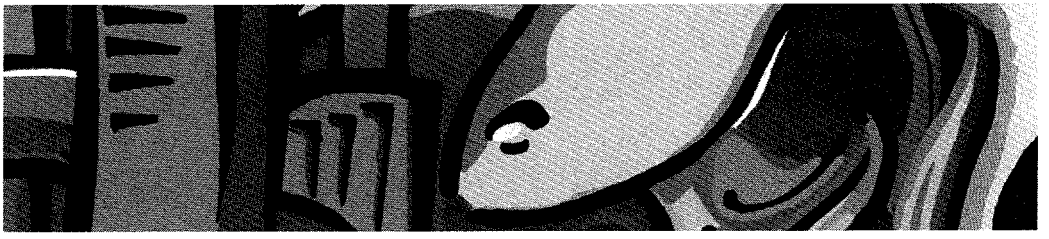
> *. . . over-reliance on a simple water chemistry approach seriously underestimates the extent of impairment of a state's waters and provides a potentially biased view of the important causes of impairment.*(Rankin and Yoder 1990, I-9)

As a result of its experience, Ohio has assumed a leadership role in the use of three biological indices for quantitatively monitoring and assessing impairment of aquatic habitat:

- the Index of Biotic Integrity (IBI, based on fish);
- the Invertebrate Community Index (ICI, based on macroinvertebrates); and
- the Index of well-being (Iwb, based on fish).

(See discussion Rankin ed. 1988, 3, and Rankin et al. 1991, 4-5.)

These direct measures of the state of the aquatic biota are now used as primary indicators in Ohio's water assessments, while water chemistry and contaminant source data are used in a supporting role. However, in its assessments, Ohio emphasizes the need for an integrated chemical, physical, and biological assessment of a water resource (Rankin and Yoder 1990, I-3).



6. Institutions and Implementation

This case study has addressed the assessment of sustainability in the Great Lakes basin ecosystem. It has explicitly taken the perspective of the ecosystem and the decision makers concerned with the region as an entity. It has done so recognizing that the ecosystem spans political jurisdictions and that, after the primary ecosystem focus defined by the drainage basin, the secondary decision-making envelope includes the eight Great Lakes states and Ontario.

Within the case study area, there is an immensely complex web of institutions with responsibilities related to the sustainability question. Within the Toronto area alone, the Crombie Commission identified dozens of institutional actors with some responsibility related just to surface waters (Barrett and Kidd 1991, 102).

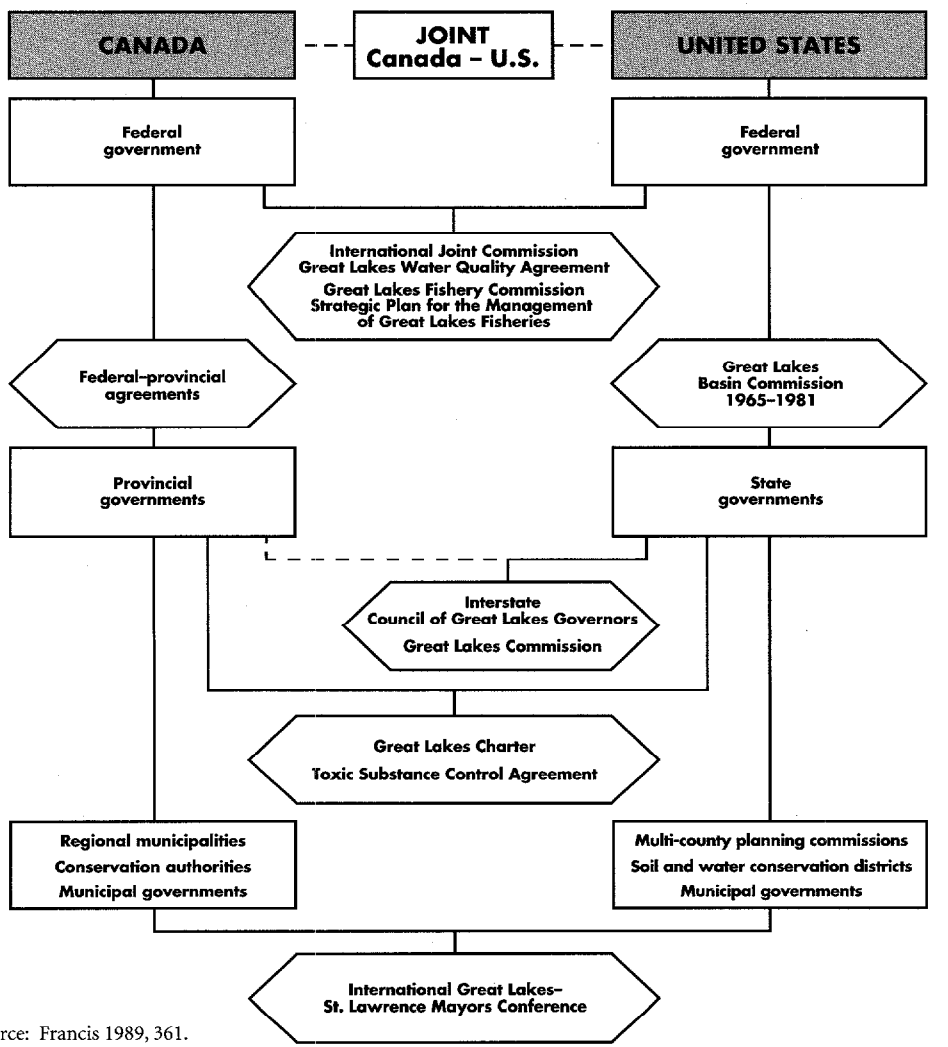
In spite of this maze of institutional players, the basic structure of governance for the Great Lakes basin is relatively simple. It is shown below in Figure 15. This figure helps to point to where the responsibility for monitoring, assessing, and reporting on progress toward sustainability for the region could and should be lodged.

The eight Great Lakes states and Ontario have a clear mandate for assessing and reporting on progress toward sustainability within their jurisdictional boundaries. More locally, counties, regional districts, municipalities, conservation authorities, and individual communities all have an important role to play within their jurisdiction. However, assessment and reporting on progress toward sustainability for a transboundary, multijurisdictional region is a more complex issue.

Ultimate responsibility for this issue lies with the federal governments of the United States and Canada, who must agree between themselves on an appropriate mechanism. Resolution of this question has not been a major focus of this case study. However, through the course of this work, it became apparent that the office or institution assigned this responsibility must meet certain criteria. It must have:

- the freedom and resources to function independently;

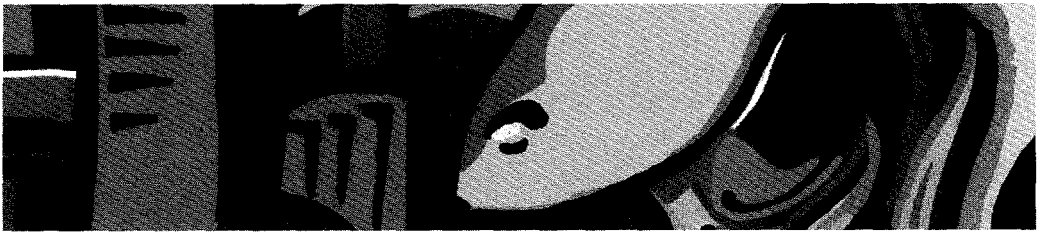
Figure 15
Basic framework of governance for the Great Lakes



Source: Francis 1989, 361.

- the stature and capability to be able to link successfully with any required element of the existing institutional web; and
- assured continuity of existence to ensure that an institutional memory is created and assessment is undertaken periodically (modified from NRTEE 1993, 44).

The only mechanism that comes near to potentially meeting these criteria is the International Joint Commission. To activate such an initiative would require a joint reference from the governments of the United States and Canada.



7. Summary

This case study is intended to be illustrative, not definitive. It is a demonstration of how judgments can be reached where there is a lack of scientific certainty about progress toward sustainability. An approach is used that attempts to weigh conflicting information to determine where the majority of evidence points.

7.1 The Great Lakes Basin Ecosystem is Not on a Path toward Sustainability

Based on the weight of evidence, it is apparent that *the Great Lakes basin ecosystem is not currently on a path toward sustainability.* In particular, ecosystem health continues to deteriorate and imposed stress continues to grow. An overall assessment of trends in human well-being is lacking, not only in terms of individuals but also in terms of communities, and institutions. On the positive side, the ability of human activities to support human well-being from a material perspective appears to be growing and the number of initiatives aimed at ecosystem restoration is likely increasing.

7.2 Significant Limitations Remain in Knowledge and Analytic Technique

The general assessment of progress toward sustainability presented earlier in Section 3 points to the following gaps in data, information (interpreted data), and analytic technique:

Domain I: Ecosystem

- systemic analytic techniques that encourage assessment of ecosystem components within the context of the whole ecosystem;
- data describing toxic contaminants in air; surface water quality of inland rivers, lakes, and streams; physical and chemical characteristics of the groundwater flow system; the state of built infrastructure; the population health status of a wide range of organisms; aquatic and terrestrial habitat; forest ecosystem health and integrity; human health and well-being (as an indicator of ecosystem health and integrity).

Domain II: Interaction

- data, information, and analytic techniques that would facilitate a systemic analysis of the imposed physical, chemical, and biological stress caused by individual human activities;
- data, information, and analytic techniques that would facilitate analysis of restorative actions and opportunities;

Domain III: People

- data, information, and analytic techniques that would facilitate a systemic assessment of overall human well-being;
- data, information, and analytic techniques that would facilitate a systemic assessment of the well-being of judicial and legislative institutions;

Domain IV: Synthesis

- historical data and information and a compilation of older knowledge that would facilitate assessment of current state and change in state (first-order change) and also change in the rate of change (second-order change); and
- techniques for identification of system properties that can be identified only by considering the whole system and are not apparent from consideration of Domains I, II, and III individually.

7.3 Detailed Subsystem Analysis is Powerful

Two subsystems were examined in detail: (1) energy production, transportation, and use (an example from Domain II), and (2) surface water and groundwater (an example from Domain I).

Energy

In assessing the energy subsystem, care was first taken to define both energy demand and energy supply as important policy-driven variables. This approach was that of soft path energy analysis. Application of the proposed methodology led to the identification of 16 required indicators that group in the following five categories:

- quantity and quality of energy produced, imported, and used;
- efficiency of transformation and use;
- imposed stress;
- longevity of energy supply; and
- restoration.

A weak conclusion was drawn that current trends do not signal overall progress toward sustainability. Available data showed a recent reduction in energy use per dollar value added. However, how much of this change has been caused by structural adjustment in the economy and how much is due to improved energy efficiency remains unknown. Since 1985, energy use per capita has appeared to be increasing after dropping in the late 1970s and early 1980s. There is an ongoing vulnerability because of a dependency on imported petroleum products and coal.

Energy analysis and energy-related data compilation, as currently practised, is seriously deficient for rigorously assessing progress toward sustainability. Only a minority of indicators dealing with per capita and total energy use and some emissions data are easily available. Indicators dealing with energy quality, efficiency, imposed stress, the longevity of supply, and restoration are not readily available although there is no technical reason to prevent their compilation. As a result, while general observations can be made about energy and progress toward sustainability, the specific actions that

can be initiated on an activity-by-activity basis cannot be identified. This situation is particularly alarming given the importance of energy to the sustainability equation.

Surface and Groundwater

The water subsystem of the Great lakes basin ecosystem is carefully defined to focus on the water itself, not the aquatic ecosystem. (It is no less important to focus on the aquatic ecosystem, but that is a different analysis.)

Twenty-three indicators were identified that group into four categories:

- groundwater – physical characteristics;
- groundwater – chemical characteristics;
- surface water – physical characteristics; and
- surface water – chemical and biological characteristics.

The conclusion reached was that in spite of documented improvements in a number of factors, the number and seriousness of identified concerns indicate that the water subsystem of the Great Lakes basin ecosystem is not yet on a path toward sustainability.

It is apparent that data and information describing groundwater flow systems and chemistry are seriously deficient. This deficiency represents a serious gap in knowledge.

In contrast, surface water has benefited from the longest attention span devoted to any ecosystem component and is relatively well understood. The only areas where data are seriously deficient are water course continuity, water use efficiency and curtailments, and rural and urban non-point sources.

7.4 The Overall Methodology has Strengths and Limitations

A number of overall conclusions regarding the methodology can be drawn. First, the proposed methodology facilitates a systematic choice of indicators, be they specific measures or aggregations.

Second, the assessment hierarchies provide a powerful tool not only for mapping the process but also as a check template for identifying gaps and emerging issues. In theory, a comprehensive assessment would methodically address each cell in each hierarchy moving up and down among more and less aggregated levels. In practice, some cells will receive greater emphasis than others, some may not be addressed at all. This emphasis will depend on local knowledge, conditions, operating values, and to some extent, the current issues of concern.

It is important to revisit periodically the broader framework – testing current ideas, identifying potential concerns, and assessing their implications. It is in this revisiting that oft-missed, overarching, and anticipatory thinking demonstrates the greatest usefulness of the conceptual framework and assessment hierarchies.

Third, data supporting Domains I, II, and III are not typically compiled on the same spatial basis. Domain I is relatively easily compiled on an ecosystem basis in spite of data gathering by agencies and individuals from many different local, state/province, and regional agencies. Data for Domain III describing human well-being are generally available by community or state/province. Data describing human activities, Domain II, are more easily available at the state/province level of aggregation but are sometimes available on a drainage basin basis as well. These boundary differences are currently unavoidable and complicate, but do not prevent, the overall synthesis that is developed as Domain IV.

Fourth, in general terms, the approach taken in this case study included two steps. It began with examination of the development history of the Great Lakes basin ecosystem over the past century. Telling this story made

possible the identification of a number of overall trends important to sustainability. A second step involved the formal assessment of progress toward sustainability moving in iterations from the general to the more specific and back again. Each element of assessment involved judgment that weighed knowns against unknowns, searched for patterns and trends and balanced probabilities in a process that draws inspiration from the common law court systems. In spite of data and knowledge limitations, this approach facilitates a well-founded judgment – one that can always be improved with better data and knowledge.

Fifth, the proposed system can be seen to be built on earlier developments including input-output ideas of early systems thinking, the stress-response ideas of Rapport and Friend (1989), and the three-part environment-economic-social natural resource use model. For example, Domain II can be thought of as input and Domains I and III as outputs. Domain II is the stress and Domains I and III are the response.

However, the labels of earlier work (along with significant definitional limitations) have been discarded in favour of those that are consistent with systems theory and reflective of the underlying value base (ecosystem, interaction, people). Most importantly, the Domain IV synthesis has been introduced. Without this synthesis, components remain isolated and emergent properties relating to the whole system will not be recognized.

Sixth, the short list of five aggregated indicators that support the Domain IV synthesis stands as a powerful set of indicators of sustainability. Each of these indicators is a complex aggregate, occupying a position high up on the indicator hierarchies – at the top of each of Domains I, II, and III – and supported by a large number of often conflicting data sets.

Seventh, each domain assessment emerges as a product of aggregation leading to judgement. While it might be possible to apply numerical analysis in the aggregation process it would be difficult to do and the results would be suspect: insights are brought to bear not only from measurement of state, trends, and changes in trends where possible, but also from intuitive knowledge and professional judgment.

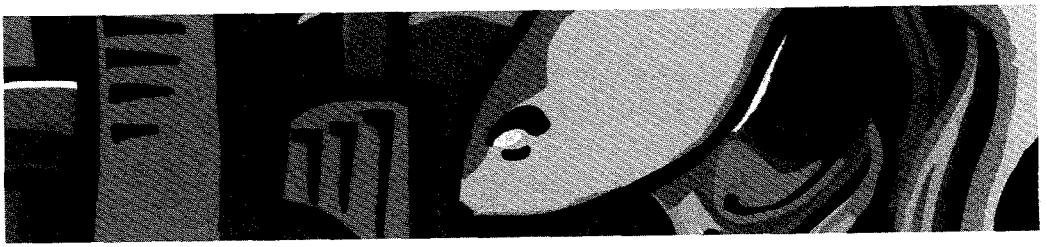
7.5 Implementation Remains Problematic

A final comment is appropriate regarding implementation of a systemic process of assessing and reporting on progress toward sustainability in the Great Lakes basin ecosystem. The institutional home for such a system does not currently exist.

In spite of an immensely complex web of institutions with responsibilities related to the sustainability question, the basic structure of regional governance is relatively simple. And while analysis of this institutional maze was not a major focus of this case study, three criteria emerged for judging the ability of an office or institution effectively to assume responsibility for assessing and reporting on progress toward sustainability in the Great Lakes basin ecosystem. The required office or institution must have:

- the freedom and resources to function independently;
- the stature and capability to be able to link successfully with any appropriate element of the existing institutional web;
- assured longevity of existence to ensure that an institutionalized memory is created and assessment is undertaken periodically (modified from NRTEE 1993, 44).

The only mechanism that comes close to potentially meeting these criteria is the International Joint Commission.



Appendix 1:

1990 Activity Indicators for the Eight Great Lakes States and Ontario

Table A1
Minnesota activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	3,075		
Agriculture services, forestry, and fisheries	357		
Mining	630		8.21
Construction	3,699		79.25
Manufacturing	19,633		398.32
Subtotal	27,394		485.78
Dynamic and traditional services			
Transportation and public utilities	7,680		108.71
Wholesale trade	6,670		125.74
Retail trade	8,509		390.94
Finance, insurance, and real estate	14,857		124.37
Services	14,447		552.49
Subtotal	52,163		302.25
Non-market services			
Federal civilian government	1,728		35.20
Federal military	230		
State and local government	7,262		303.17
Subtotal	9,220		338.37
Gross state product	88,777	**Total employment**	2,126.40
Household contribution to value added (not in GDP)[1]	31,516		
Contribution to value added from volunteer activities (not in GDP)[2]	1,980		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A2
Wisconsin activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	2,696		
Agriculture services, forestry, and fisheries	423		
Mining	139		2.26
Construction	3,419		81.01
Manufacturing	25,960		559.66
Subtotal	32,637		642.93
Dynamic and traditional services			
Transportation and public utilities	7,162		106.31
Wholesale trade	5,377		117.78
Retail trade	8,200		420.36
Finance, insurance, and real estate	14,373		119.86
Services	12,974		531.18
Subtotal	48,086		1,295.49
Non-market services			
Federal civilian government	1,332		30.21
Federal military	226		
State and local government	7,173		311.66
Subtotal	8,731		341.86
Gross state product	89,454	**Total employment**	2,280.30
Household contribution to value added (not in GDP)[1]	31,756		
Contribution to value added from volunteer activities (not in GDP)[2]	2,084		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A3
Indiana activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	1,762		
Agriculture services, forestry and fisheries	345		
Mining	830		8.07
Construction	4,142		119.32
Manufacturing	30,432		634.98
Subtotal	37,511		762.37
Dynamic and traditional services			
Transportation and public utilities	9,797		132.03
Wholesale trade	5,643		126.53
Retail trade	10,326		473.46
Finance, insurance, and real estate	13,924		122.79
Services	13,390		530.25
Subtotal	53,080		1,385.06
Non-market services			
Federal civilian government	1,802		46.28
Federal military	385		
State and local government	7,143		329.81
Subtotal	9,330		376.06
Gross state product	99,921	**Total employment**	2,523.47
Household contribution to value added (not in GDP)[1]	35,472		
Contribution to value added from volunteer activities (not in GDP)[2]	2,228		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A4
Michigan activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	1,582		
Agriculture services, forestry, and fisheries	547		
Mining	1,020		9.26
Construction	6,228		139.98
Manufacturing	48,244		940.23
Subtotal	57,621		1,089.47
Dynamic and traditional services			
Transportation and public utilities	13,087		157.10
Wholesale trade	10,795		199.33
Retail trade	16,257		745.12
Finance, insurance, and real estate	26,179		191.12
Services	27,555		938.52
Subtotal	93,873		2,231.19
Non-market services			
Federal civilian government	2,003		61.36
Federal military	510		
State and local government	14,839		567.23
Subtotal	17,352		628.57
Gross state product	168,847	**Total employment**	3,949.23
Household contribution to value added (not in GDP)[1]	59,940		
Contribution to value added from volunteer activities (not in GDP)[2]	3,765		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A5
Ohio activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	1,761		
Agriculture services, forestry, and fisheries	626		
Mining	1,386		17.57
Construction	7,681		198.45
Manufacturing	55,462		1,111.74
Subtotal	66,916		1,327.76
Dynamic and traditional services			
Transportation and public utilities	17,577		219.69
Wholesale trade	12,761		262.83
Retail trade	19,593		910.75
Finance, insurance, and real estate	30,172		254.87
Services	31,790		1,195.63
Subtotal	111,893		2,843.77
Non-market services			
Federal civilian government	3,476		98.03
Federal military	748		
State and local government	14,760		626.19
Subtotal	18,984		724.22
Gross state product	197,792	**Total employment**	4,895.78
Household contribution to value added (not in GDP)[1]	70,217		
Contribution to value added from volunteer activities (not in GDP)[2]	4,410		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A6
Ontario activity indicators for 1990 (contribution to value added and employment by industry[3])

Industry	Value added[4] (US$ millions 1987)		Employment (thousands)
Goods producing			
Manufacturing	47,814		966
Construction	12,019		324
Utilities	5,325		60
Agriculture	2,572		138
Mining	2,320		35
Forestry	537		17
Fishing, hunting, and trapping	49		3
Subtotal	70,636		1,543
Dynamic and traditional services[5]			
Finance, insurance, and real estate	34,081		302
Commercial, business, and personal services	30,763		727
Wholesale and retail trade	22,717		744
Transportation, communication and storage	14,240		255
Subtotal	101,801		2,028
Non-market services[6]			
Education services	9,438		287
Health and social services	7,413		78
Federal administration and defence	6,859		158
Local administration	2,935		84
Provincial administration	2,568		66
Subtotal	29,213		973
GDP at factor cost	201,650	**Total employment**	4,544
GDP at market prices[7]	228,900		
Household contribution to value added (not in GDP)[8]	81,300		
Contribution to value added from volunteer activities (not in GDP)[9]	4,500		211

Table A7
Pennsylvania activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	1,722		
Agriculture services, forestry, and fisheries	807		
Mining	1,972		27.51
Construction	9,779		228.70
Manufacturing	44,868		1,014.92
Subtotal	59,148		1,271.13
Dynamic and traditional services			
Transportation and public utilities	21,668		266.37
Wholesale trade	13,535		277.37
Retail trade	20,708		904.36
Finance, insurance, and real estate	38,823		300.23
Services	41,941		1,450.41
Subtotal	136,675		3,198.74
Non-market services			
Federal civilian government	5,308		142.62
Federal military	882		
State and local government	14,830		564.91
Subtotal	21,020		707.52
Gross state product	216,842	**Total employment**	5,177.40
Household contribution to value added (not in GDP)[1]	76,972		
Contribution to value added from volunteer activities (not in GDP)[2]	4,835		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A8
Illinois activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	2,771		
Agriculture services, forestry, and fisheries	875		
Mining	1,746		19.78
Construction	10,589		218.15
Manufacturing	47,793		983.73
Subtotal	63,774		1,221.66
Dynamic and traditional services			
Transportation and public utilities	24,060		307.70
Wholesale trade	19,964		357.74
Retail trade	22,246		900.34
Finance, insurance, and real estate	45,200		375.46
Services	44,750		1,340.04
Subtotal	156,220		3,281.28
Non-market services			
Federal civilian government	4,404		113.57
Federal military	1,413		
State and local government	16,363		648.80
Subtotal	22,180		762.38
Gross state product	242,174	**Total employment**	5,265.32
Household contribution to value added (not in GDP)[1]	85,972		
Contribution to value added from volunteer activities (not in GDP)[2]	5,400		

Sources: Value added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Table A9
New York activity indicators for 1990 (contribution to value added and employment by industry)

Industry	Value added (US$ millions 1987)		Employment (thousands)
Goods producing			
Farms	1,417		
Agriculture services, forestry, and fisheries	925		
Mining	457		5.39
Construction	15,850		314.28
Manufacturing	60,963		1,131.17
Subtotal	79,612		1,450.84
Dynamic and traditional services			
Transportation and public utilities	37,906		428.29
Wholesale trade	29,311		465.95
Retail trade	33,687		1,218.85
Finance, insurance, and real estate	101,855		777.01
Services	87,951		2,395.85
Subtotal	290,710		5,285.95
Non-market services			
Federal civilian government	5,862		168.68
Federal military	1,249		
State and local government	38,494		1,303.21
Subtotal	45,605		1,471.88
Gross state product	415,927	**Total employment**	8,208.65
Household contribution to value added (not in GDP)[1]	147,654		
Contribution to value added from volunteer activities (not in GDP)[2]	9,275		

Sources: Value Added: Regional Economic Analysis Division, Bureau of Economic Analysis, Washington; Employment: Federal Reserve Bank of Chicago.

Endnotes – Appendix 1

1. This estimate of the value added of household work in the eight Great Lakes states is based on the work undertaken by Statistics Canada for the 10 provinces of Canada. It is calculated using a figure of 35.5 percent of gross state product. See endnote 8.

2. This estimate of the value added of volunteer activities is based on figures for Ontario developed by Statistics Canada. It is calculated using a figure of 2.23 percent of gross state product. See endnote 9.

3. Because of the variety of data sources, figures must be considered rough estimates. However, they are useful for indicating relative contributions.

4. Conference Board of Canada 1991 estimates unless otherwise noted.

5. The service sector structure is from Betcherman et al. 1991.

6. Value added figures for non-market services are estimated from both Conference Board of Canada 1991 and Statistics Canada 1990b.

7. Ontario Office of Economic Policy 1992. The difference between this figure and the total of contributions to value added by the various components is accounted for by the addition of indirect taxes minus subsidies.

8. Estimates of the value of household work (VHW) in Canada are given by Jackson 1992. Using both opportunity cost and replacement cost valuation methods, he estimates that the VHW in Canada ranges from 32 percent to 39 percent of GDP. The figure in Table A6 is simply the average of these percentages applied against the 1990 GDP figure. VHW is not included in calculation of GDP.

9. D.P. Ross 1990. Ross estimates the economic value of volunteer activities in 1986/1987. The figure for value added used in these tables has been modified upward slightly to approximate 1990 conditions. For example, figures for Ontario were adjusted from $4.2 to $4.5 billion. This latter figure represents 2.23 percent of gross provincial product. This proportion was used to generate the figures for the eight Great Lakes states. The figure in the employment column (Ontario only) is Ross's estimate of volunteer hours as full-time equivalent positions. For Ontario, this represents 5.3 percent of all full-time employees.

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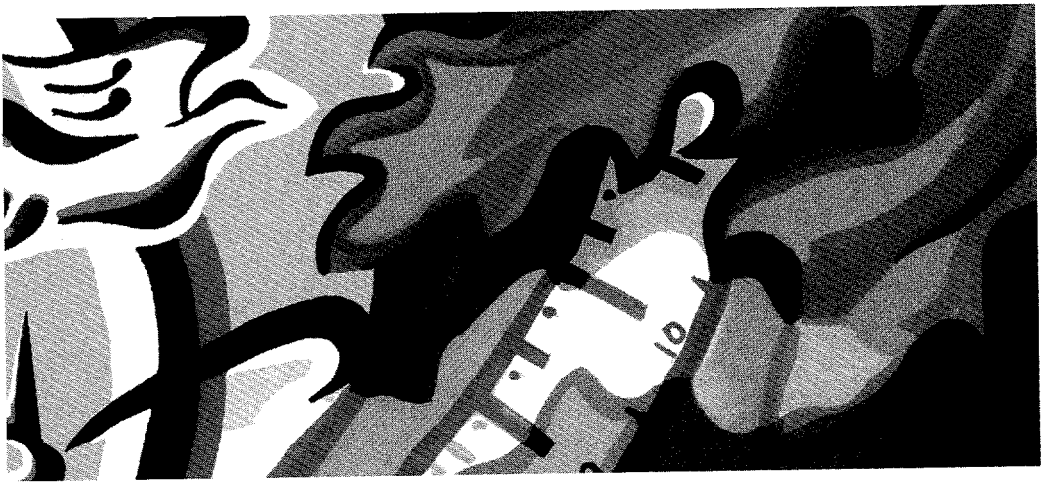
Part IV



Anticipating the Future

Anticipating the Future

If people see things differently, they will do things differently. That proposition lies at the core of all that is presented in this book. It suggests that the lens through which people perceive issues will determine the questions they ask, the answers they develop, the actions they undertake. Change the lens and the questions change, and so do answers and actions. Our reflections on the work compiled in parts I, II, and III of this book, and in particular the implications for the future, are presented in the pages that follow.

From the opening preface, and through all that follows in this book, it has been emphasized that the lens used by the National Round Table's Task Force on Sustainable Development Reporting was shaped by:

> *a parallel concern and respect for people and for the enveloping ecosystem – not one or the other, not one more than the other, but both together.*

It was from this way of looking at sustainability that the four indicator domains were developed in Tony Hodge's Ph.D. thesis, and an assessment was made of progress in the Great Lakes basin ecosystem in that portion of the thesis presented in this book. It was from this perspective that the Report to the Prime Minister was developed. And it was the use of this lens that underlay discussion at the colloquium.

As a result of all that is recorded in this book, the Task Force on Sustainable Development Reporting is reaffirmed in its conviction that this approach provides a firm foundation for shifting to a value system that will ensure solid progress toward sustainability.

However, it is no easy thing to ask people to see themselves as no more and no less than a subsystem of a larger, encompassing ecosystem. It presumes a scale of importance in which individuals and communities will not always come first; in which fish stocks, or spotted owls, or carbon dioxide levels can command as much concern as families with jobs at stake and mortgages to pay.

Consequently, it is important to stress that the concept of parallel concern and respect implies a commitment that the people adversely affected by sustainability decisions will not bear the full brunt of the impact; that

just as there will be a sharing in the benefits, so there should be a sharing to ease the more disruptive impacts. From that perspective, human well-being is not only an essential component of sustainability, it represents a public commitment without which it is questionable whether broad support can be won for the magnitude of change that sustainability demands.

The Need for Anticipatory Thinking

The mainspring of progress toward sustainability is anticipatory thinking. Again and again speakers in the colloquium stressed the need to look ahead, to try to discern trends, analyse change, forestall undesirable developments, and enlarge on progress. It is only by assuming this stance and acting (sometimes courageously) as a result, that the costly human and environmental crises of yesterday and today can be avoided for tomorrow. One need only look to the field of trade to see how important is this type of thinking. Trade is, and throughout history always has been, a dynamic for change. And right now there are enormous changes taking place – in global restructuring, in shifting regional balances, in technologies and techniques, in trading patterns, in standards of living, in products, in individual and corporate behaviour, in any and all areas touched by trade. One of the greatest challenges to humankind is to direct these changes toward sustainable development.

However, history is almost devoid of long-term anticipatory thinking when it comes to economic development and its ecological and social impacts. Again and again we bring crises down upon ourselves. It is a rare exception when current human decision making considers a time horizon beyond a few years.

The ideas of sustainability and sustainable development challenge this short-term perspective. By explicitly linking human and ecosystem well-being, the time horizon of decision making is stretched. It is only by accounting for the long time horizon governing ecosystem functions that ecosystem well-being can be considered and assessed.

In practice, such anticipatory thinking is difficult. Ecosystems change and evolve – but so do human values that must be brought to bear in assessing the significance of such changes. In other words, not only might the social and environmental landscape be changing in ways that had been hoped for, or feared, but the criteria for judging the changes might be shifting as well.

Because of this dynamic condition, it might be an impediment to anticipatory thinking if a short list of indicators locked to what we currently identify as "concerns" were entrenched. When the issue is accountability – measuring performance that results from specific policies – there is a place for adopting indicators that do not alter over given periods of time. It is a retrospective exercise, looking back to see the consequences of implementing policies so that decisions can be made on whether to continue or to revise them. Consequently, there has to be consistency in the measuring stick. Data must be comparable over time. But addressing a future in which everything can change is not a straight-line exercise. As ecospheres evolve and adapt, and as human needs and desires change, there has to be a capacity to reassess. When the future turns unexpected corners, it may mean relinquishing old patterns of thought and measurement and searching for new ones.

Basic to any anticipatory synthesis is not only an understanding of human and ecological trends, but also a practical appreciation of the

needs of decision makers – and that means identifying and accepting their mindsets in a non-judgmental way. It means using their values and their needs as the context within which trends and remedies are discussed, and proposals are developed. It is through this kind of practicality that a synthesis becomes very powerful.

In many ways, it means a small-scale approach to large-scale problems. In the first place, decision makers usually have narrowly defined responsibilities. The specific needs of a cheesemaker may be quite different from those of a shoe manufacturer, even though they may be located in the same town.

Moreover, Canada is a country of regions, each with differing characteristics, both human and ecological, each with its own idiosyncrasies. That presents a challenge to developing national plans, or even provincial plans. It may not be easy, for instance, for policymakers in Ottawa to enter the mindsets of decision makers in different provincial governments, and even more difficult to enter the mindsets of decision makers in the variety of communities in each of the various regions, or the mindsets of householders within those communities.

Approaching a specific social, economic, or environmental problem may require several syntheses, each applicable to decision makers in a different region, or to decision makers with different needs. What works as a synthesis in one area may not work in another. What works for one decision maker may not work for another. In short, once an issue or a problem is anticipated, it may mean approaching the whole by approaching its many parts, and doing so under the umbrella of a single objective.

It is no easy task to put oneself into the heads of others. It is suggested here that the task is best approached with a healthy measure of humility.

What is the Good Life?

The report to the Prime Minister (Part I) framed indicator domains under four categories – ecosystem integrity, human-ecosystem interaction, the well-being of people (and their communities, institutions, and businesses), and synthesis. Not surprisingly, the colloquium (Part II) was least successful in grappling with the "people" domain and the concept of human well-being. Issues in this domain are much more subjective and less open to measurement.

Debate seemed to swirl around in search of solid footing – and found none or, at least, very little. In contrast, participants vigorously debated issues concerning ecosystem integrity, even though different views were held and different approaches were taken. And the same can be said for human-ecosystem interaction. In each of these latter two domains there are huge and perplexing problems. But at least there are recognized assumptions that can be made in each field, and there is an intellectual history and a momentum in dealing with them.

Such is not the case with human well-being. Most of the work being done in this field falls within disciplines outside what normally have been regarded as ecological studies: psychology, for instance, or landscape and urban design, or social policy at the community service level. There is not yet a full acknowledgement of the need to include the human dimension – issues of quality of life and happiness, and how they can be measured – as an essential part of assessing progress toward sustainable development.

Nor is there the slightest cross-disciplinary agreement on what quality of life means. Disease related to toxic emissions, even with all the controversy surrounding linkages, is one of the easier aspects to address. But what about mental states? Is severe depression something

to be considered in assessing ecosystem health? What about standards of living? Recreational opportunities? Community pride? Literacy? Obesity? Stress? Satisfaction with the conditions of life? Aesthetics?

Excellent work on the quality of life was being done in the 1960s and 1970s in land-use planning and other disciplines. Unfortunately, in the late 1970s, it seemed to stall through an inability to resolve methodological difficulties, especially in the field of measurement. Assessing quality of life is now re-emerging as a focus of enquiry, particularly at the community level.

What the colloquium highlighted was the lack of a touchstone, common to the environment, the economy, and human well-being, that can mark the entry point for integrating all three dimensions. In fact it highlighted the lack of such a touchstone among the multitude of disciplines that focus on human well-being by itself alone. Without a touchstone, participants in the colloquium had too little in the way of commonly accepted language, or techniques, or concepts to address total integration.

On the other hand, integration of the economy and the environment is progressing precisely because an intellectual process has evolved that recognizes the methodology and the concepts of both domains. There are disagreements on specific issues, of course. But the disputants are on grounds much more familiar to them and, consequently, in a much better position to resolve differences. Although the exercise of integrating the economy and the environment touches on certain aspects of human well-being, it does not begin to bear on the panoply of issues that the field embraces.

It may be that the area of human values can provide the needed touchstone. All decisions can ultimately be traced back to values. And it goes almost without saying that integration will be next to impossible if there is not a clear focus on values and an understanding of how they manifest themselves in decision making.

In some cases of business and governmental decision making, human values already lie close to the surface. For instance, quality of life is a prime consideration behind municipal land-use planning regulations that prescribe such things as open space, the heights of buildings and the trajectory of their shadows, minimum light requirements for residential rooms, and so on. Developers of luxury apartment buildings often exceed the quality-of-life requirements in order to attract upscale tenants.

There are many other examples that suggest dealing with values as a determining factor in decision making would not be a foreign exercise. To bring it to the forefront, however, would constitute a new point of departure. That said, it would be a point of departure with a powerful logic behind it. Values determine goals, and goals determine action. Taking the steps in logical sequence would mean settling basics before addressing the mechanics of integration.

That, of course, is easier said than done. Debates on values reach back through all civilized discourse. Nevertheless, we live at a turning point. Perhaps we should return to the traditional question of Greek philosophy and ask, "What is the good life?" There may be no definitive answer, and it may be that in the present era of rapid and unpredictable change, there is no universal truth that can be pursued. Maybe the issue should be approached from a Hegelian perspective that accommodates constant transformation instead of striving for certainty. Maybe instead of answers, the search should be for never ending cycles of thesis, antithesis, and synthesis.

Whatever the underlying philosophic basis, the process of trying to cope with the question of what is the good life would, in itself, be extremely important. It would emphasize how central to every human activity are the values upon which action is based. And how central they are to any consideration of sustainable development in general – as any discussion of biodiversity makes immediately apparent. It would provide a common language that can link the various perspectives from which sustainable development is viewed – the economy, the environment, human well-being – in a way that could rapidly facilitate integration.

However, the focus will have to be on human values as they are and as they function, and not as they ought to be. If the starting point becomes a utopian vision of how society should operate and how people and their institutions should act, motivation for change will be minimal. People do not shift behavioural patterns because they want to leap into an imagined utopia. They shift, generally in small increments, because the move conforms with values already embraced and because it offers tangible benefits.

Moreover, it would be supremely contemptuous to argue that anyone should abandon existing values for a new, utopian set. Respect for individuals includes the notion that they have good reasons for acting as they do. Prescribing utopian remedies would assume there is no need to examine and understand those reasons.

Nevertheless, throughout history utopian visions have had tremendous power and perhaps there is a way to reap the advantages of a utopian vision while remaining grounded in the practicalities of modifying behavioural patterns according to perceived values and tangible benefits.

Judging According to the Weight of Evidence

The colloquium demonstrated that when it comes to overall synthesis, which is the fourth indicator domain, there is difficulty framing the questions to ask. The problem seems to lie not in a lack of knowledge or skill, but in a lack of confidence that normally would come from trial and error. As with anything else, practice reassures and emboldens. The interesting thing about attempting synthesis is that after the domains are established, the indicators identified, and the data gathered, questions can follow quite naturally. It is only with this synthesis that emergent properties of the whole can be seen that are not apparent from the parts.

It has been the contention throughout this work that scientific certainty is elusive, and consequently, judgments will have to be made on the weight of evidence if syntheses are to be reached. However, making decisions according to the weight of evidence is a controversial issue, especially when it concerns the impact of pollutants, a demand for regulation, and the assignment of costs.

Courts of law make decisions all the time based on the weight of evidence. The process of coming to decisions is predictable. There are rules of evidence that fill volumes governing what is admissible, what is inadmissible, and how evidence can be presented and tested. It is only after the rules are observed that the weighing can begin.

A full set of objective standards has not yet been developed to govern the quality of evidence in sustainability issues, and that raises two separate points: one concerned with the progress being made, and the other with what regulations should be implemented. Judging progress does not, of itself, impose

costs or restrictions, although it may increase the pressure for them. Regulations do, of course, impose them.

When it comes to imposing costs or restrictions a start has been made in developing procedures for sifting evidence. In cases where there is an environmental assessment required by law, for instance, there are established procedures to follow. And when environmental issues reach the courts, there is case law determining how rules of evidence apply to environmental issues.

A much broader canvas is used in judging progress toward sustainability. Is it necessary to wait until there is a consensus on what standards and procedures should prevail before judgments are made on progress toward sustainability? The answer to this question can only be no. The luxury of waiting for perfection is not a realistic option. The approach should be to make do with the best evidence that can be mustered and to let the quality of the ensuing analysis stand before public opinion. Let it be savaged or supported. In the meantime, a body of case histories will be created. Once they are assembled, decisions can be reconciled, approaches can be rationalized, rules and procedures can be devised, and opinions can be rejected or modified. But at the very least, a record of observation will be developed and a sense of which methodologies work and which do not will be acquired. That is how the common law grew. That is how the concept of the weight of evidence evolved.

The case study illustrates how judgments can be pieced together from available information. The study concludes that:

> *The Great Lakes basin ecosystem is not currently on a path toward sustainability. In particular, ecosystem health continues to deteriorate and imposed stress continues to grow. An overall assessment of trends in human well-being is lacking, not only in terms of individuals, but also in terms of communities and institutions. On the positive side, the ability of human activities to support human well-being from a material perspective appears to be growing and the number of initiatives aimed at ecosystem restoration is likely increasing. (Page 203)*

Among other things, the study demonstrates what kind of standard should be expected in arriving at a judgment. It sets a framework, it charts linkages, it assembles data, and it establishes a process for analysis. It offers an example of the kind of comprehensive methodology that should be expected. And it shows what a benchmark can look like. In short, it makes a case for judging according to the weight of evidence.

Where Past and Future Meet

There is an urgency to move quickly on all these items – on learning how to assess human well-being within the context of sustainability, on developing skills in anticipatory thinking, on exploring how to gauge the good life, and on coming to judgments based on the weight of evidence – because, for the first time in recorded history, all ecosystems, including the people within them, are at risk. And we, as a single species, are responsible. In a sense, we hold all other species hostage to our needs and ambitions, and our impact in many ways is exponential. We are at what T. S. Eliot called "the still point of the turning world," where past and future meet, where what has been and what might have been converge.

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Assessing Our Progress

edited by Tony Hodge, Susan Holtz, Cameron Smith, and Kelly Hawke Baxter

Canadian decision makers do not have adequate information on which to base sound decisions concerning sustainable development, to set realistic goals, or to measure progress toward those goals. After nearly a decade of discussing the ideas of the Brundtland Commission, we still cannot answer basic questions: Is Canada progressing toward sustainable development? If so, how fast, and if not why not?

Pathways to Sustainability recommends ways to improve Canada's ability to gather the information decision makers need to assess progress. This book shows how sustainability can be measured and evaluated, by proposing a framework for a reporting system and demonstrating how it works, using the Great Lakes basin ecosystem as a case study.

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ISBN 1-895643-29-5

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