FRASER RIVER ACTION PLAN

Towards an Ecosystem Approach in British Columbia

Results of a Workshop on Ecosystem Goals and Objectives
December 7 to 9, 1992

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Towards an Ecosystem Approach in British Columbia

Results of a Workshop on Ecosystem Goals and Objectives December 7 to 9, 1992

Prepared for

Environment Canada
British Columbia Ministry of Environment, Lands and Parks
British Columbia Ministry of Forests

by

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Executive Summary

This report is a summary of a workshop on Ecosystem Goals and Objectives, held at Dunsmuir Lodge from December 7-9, 1992. The workshop was planned by a Steering Committee consisting of personnel from Environment Canada, the British Columbia Ministry of Environment, Lands and Parks, and the British Columbia Ministry of Forests. This workshop reexamined traditional management approaches, and wrestled with the problem of how to apply an *ecosystem approach* to the management of aquatic and terrestrial ecosystems in British Columbia.

The ecosystem approach understands that humans are an integral part of the ecosystem. It combines a holistic or systems approach to science with an understanding of the social and economic factors that influence human attitudes and behaviour. Participants in the workshop explored the value of this approach through both presentation sessions by invited experts and the working group discussions.

The main objective of the workshop was to increase understanding of ecosystem goals and objectives: how to set them and how to implement them. Ecosystem goals are generally qualitatively described and correspond to broad intentions. They deal with the questions: "What do you want?", and "What is most important?". Goals suggested at the workshop fell into five general categories: biology/conservation, resource use, aesthetics, socioeconomic, and planning. Ecosystem objectives, on the other hand, tend to be more specific and can be defined in quantitative terms. They define the system properties required to attain these goals, the indicators necessary to measure movement towards these objectives, and targets for these indicators.

In the presentation sessions, invited experts first provided a strong conceptual foundation for the meeting by defining ecosystems and the ecosystem approach. This was followed by a series of case histories and practical examples of how ecosystem goals and objectives have been developed and implemented in specific regions. Speakers described how their organizations implemented the ecosystem approach, and faced technical and institutional challenges.

In the workgroups, participants experimented with the process of setting ecosystem goals and objectives. The following 7-step process was synthesized from workshop discussions as a useful procedure: identify and map the area of interest; develop knowledge bases; hold multi-stakeholder meetings to define goals; execute sustainability analyses; conduct adaptive management meetings to set objectives; monitor to evaluate management; and iterate (revise goals, objectives, or management).

The workshop also affirmed the importance of including the public in the development and implementation of an ecosystem approach. Four challenges to full public participation were identified and discussed: educating participants, producing results, avoiding confusion and burnout, and changing institutions. Workgroups offered practical suggestions on how to overcome each of these obstacles.

Workshop participants also discussed the challenges and opportunities posed by the ecosystem approach. The primary challenges identified by speakers and participants were: the lack of financial resources, the departmentalized structure of knowledge that restricts interaction and data-sharing among disciplines, problems of scale when setting goals and objectives, knowledge uncertainty, and leadership. Participants discussed ways of turning these challenges into opportunities for innovation and creative change. This would involve the development of new skills (such as conflict resolution and trade-off analyses), the incorporation of uncertainty into management decisions, expanding the range of agencies and levels of government that implement the ecosystem approach, and providing leadership and direction that encourages creative thinking and innovation.

Overall, participants were very positive about the workshop, and eager to do some test applications of the approach. Institutional commitment at all levels was recognized as a critical prerequisite if success is to be achieved.

Sommaire

Ce rapport présente un exposé récapitulatif d'un atelier sur les Buts et Objectifs écosystémiques qui s'est tenu au Dunsmuir Lodge du 7 au 9 décembre 1992. L'atelier a été prepare par un Comité directeur composé de représentants d'Environment Canada, du ministère de l'Environment, des Terres et des Parcs de la Colombie-Britannique et du ministère des Forêts de la Colombie-Britannique. Cet atalier avait pour objet de réexaminer les approches traditionnelles de gestion et de s'attaquer au problème des modalités d'application d'une *approche écosystémique* dans la gestion des écosystèmes aquatiques et terrestres en Colombie-Britannique.

L'approche écosystémique repose sur le principe que l'être humain est partie intégrant de l'écosystème. Elle combine une demarche holistique ou systémique dans le domaine scientifique et la connaissance des facteurs sociaux et économiques qui influent sur les attitudes et le comportement humains. Les participants à l'atelier ont exploré la valeur de cette approche au cours de séances de présentation animées par des experts invités et lors des discussions en groupe de travail.

L'atelier avait pour principal objectif d'améliorer la connaissance des buts et objectifs écosystémique: comment les fixer et comment les mettre en oeuvre. Les buts écosystémiques sont généralement décrits sur le plan qualitatif et correspondent à des intentions de principe. Ils traitent des questions suivantes: «Que désirez-vous?», et «Quelle est la chose la plus importante?» Les buts proposés à l'atelier se répartissaient en cinq categories générales: biologie/conservation, utilisation des ressources, esthétique, aspects socioéconomiques et planification. Par contre, les objectifs écosystémiques tendent à être plus particuliers et peuvent se définir en termes quantitatifs. Ils caractérisent les propriétés du système requises pour atteindre ces objectifs, les indicateurs nécessaires pour évaluer la progression vers ces objectifs et les cibles de ces indicateurs.

Dans les séances de présentation, les experts ont d'abord exposé une analyse conceptuelle solide de l'objet de la réunion en définissant les écosystèmes et l'approche écosystémique. Cette introduction a été suivie d'une série d'histoires de cas et d'exemples pratiques du mode d'élaboration et de mise en oeuvre des buts et objectifs écosystémiques dans certaines régions. Les intervenants ont décrit comment leur organisation a mis en oeuvre l'approche écosystémique et comment elle a fait face aux défis techniques et institutionnels.

Dans les groupes de travail, les participants ont expérimenté le processus d'établissement des buts et objectifs écosystémiques. Le processus suivant en 7 étapes a été élaboré à partir des discussions en atelier et offre une démarche utile: localiser la zone d'intérêt et en dresser une carte; créer des bases de connaissances; tenir des réunions plurisectorielles pour définir les buts; exécuter des analyses de durabilité; diriger des réunions de gestion adaptative pour fixer les objectifs; assurer une surveillance pour évaluer la gestion et réitérer cette démarche (réviser les buts, les objectifs ou la gestion).

L'atelier a également corroboré l'importance de la participation du public à l'élaboration et à la mise en oeuvre d'une approche écosystémique. On a cerné et examiné quatre défis à une pleine participation du public: l'éducation des participants, la production de résultats, les risques de confusion et de court-circuit et la modification des institutions. Les groupes de travail ont formulé des suggestions pratiques sur les moyens de surmonter chacun de ces obstacles.

Les participants ont aussi discuté des défis et des possibilités que présente l'approche écosystémique. Les principaux défis relevés par les intervenants et les participants étaient le manque de ressources financières, la structure compartimentée des connaissances qui limite l'interaction et le partage des données entre les disciplines, les problèmes d'échelle dans l'établissement des buts et objectifs, l'incertitude dans les connaissances et le leadership. Les participants ont discuté des moyens de transformer ces défis en possibilités d'innovation et de changement créateur. Cette opération impliquerait le développement de nouvelles compétences (comme la résolution de conflits et les analyses d'arbitrage), l'intégration de l'incertitude dans les décisions de gestion, l'expansion du réseau d'organismes et des paliers de gouvernements qui mettent en oeuvre l'approche écosystémique ainsi que le leadership et l'orientation qui favorisent la pensée créatice et l'innovation.

Dans l'ensemble, les participants ont été très positifs au sujet de l'atelier et impatients de mettre à l'essai certaines applications de l'approche. L'engagement institutionnel à tous les niveaux a été reconnu comme une condition préalable cruciale à la garatie du succès.

Foreword

The Ecosystem Objectives Workshop was an initial step in developing an understanding of the ecosystem approach to environmental management and its implications for British Columbia. To build on the workshop foundation, an ad hoc Federal/Provincial Steering Committee was formed to make recommendations on how the ecosystem approach can be implemented and to explore the development of ecosystem goals and objectives at a pilot-scale level. This committee will be the lens focusing the efforts of divergent government and non-government sectors onto the common interest of ecosystem health.

The Committee is charged with beginning the process of developing the tools necessary for monitoring the state of whole ecosystems. It is envisioned that these will be quantitative targets providing early warning of ecosystem dysfunction and thereby increasing the value of current monitoring efforts. These are the next generation inputs to State of the Environment (SOE) reporting. They will also be useful in assessing whether we are achieving the goals of particular management practices or the various local to regional planning processes that are being implemented in British Columbia.

The Committee will be coordinated closely with the activities of regional Roundtables, Ecological Science Centres (SOE), and the Fraser Basin Management Board. The development of ecosystem objectives protocols will be completed within the mandated time frame of the Fraser Basin Management Board.

Questions regarding the Ecosystem Objectives Steering Committee may be directed to the co-chairs:

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1.0 Introduction

1.1 Background

This report is a summary of a workshop on Ecosystem Goals and Objectives, held at Dunsmuir Lodge from December 7-9, 1992. This workshop reexamined traditional management approaches, and developed an *ecosystem approach* to the management of aquatic and terrestrial ecosystems in British Columbia.

This workshop was a first attempt to harness the joint creativity of B.C. environmental managers and ecosystem approach practitioners from other jurisdictions. Over 100 people attended the meeting, including fifteen invited experts (with skills in freshwater, forest, landscape, and marine ecology; public participation; and environmental monitoring), and eighty middle- to senior-level managers and scientists from provincial and federal agencies. (See Appendix A for a list of participants.) Together, they helped provide a preliminary assessment of how this approach could be applied to B.C.'s current and future environmental management and regulatory challenges.

The workshop was planned by an Organizing Committee consisting of personnel from Environment Canada, the British Columbia Ministry of Environment, Lands, and Parks, and the British Columbia Ministry of Forests. ESSA Environmental and Social Systems Analysts Ltd. organized and facilitated the meeting, and wrote this report.

1.2 Defining the Ecosystem Approach

This section attempts to define the characteristics of the ecosystem approach. This description is based both on the literature (a package of background material was distributed to participants before the workshop) and on the workshop presentations and discussions.

Modern environmental problems have pushed the limits of both science and management. Their scale and complexity challenge the traditional organization of knowledge into disciplines and the current arrangement of institutions by sector and jurisdiction. The resulting search for better and more appropriate ways of organizing and integrating science and management has produced *the ecosystem approach* to environmental research and management.

The term "ecosystem approach" has been used in a variety of contexts and has many meanings. There is no single, universally accepted definition. In general, however, the term is used in one of two ways. The first is a purely *scientific* one in which the "ecosystem approach" refers to a holistic or systems approach to research and evaluation.

On a much broader level, "ecosystem approach" is used to refer to an *institutional or societal paradigm* which views humans as part of a much larger ecosystem. This approach combines emerging ecological approaches to science with an understanding of the social and economic factors that shape human attitudes, perceptions, and behaviour.

In a review of ten ecosystem approaches to Great Lakes basin management, Lee et al. (1982) identify the following characteristics as central elements of most ecosystem approaches:

- an ecological focus (as opposed to examining purely engineering, economic or jurisdictional phenomena) with an emphasis on the interrelationships among ecosystem components;

- a perception of the ecosystem as self-regulating, yet ultimately limited in its recovery capacity;

- a recognition of the marked responsiveness of ecosystems to natural and human activities; and

- a pragmatic willingness to integrate both reductionist and holistic techniques and perspectives in a flexible approach to problems.

Also with reference to the Great Lakes, Francis and Regier (1991) have defined the ecosystem approach as:

- geographically comprehensive, covering the entire system including land, air, and water;

- including humans as a central factor in the well-being of the system; and

- a framework for decision making that compels managers and planners to cooperate in devising integrated strategies of research and action to restore and protect the integrity of the system for the future.

In his presentation at the workshop, Dr. Stan Rowe defined ecosystems as subdivisions of the global ecosphere, vertical chunks which include air, soil, or sediments, water and organisms (including humans). Ecosystems occur at various scales, from the global ecosphere, to continents and oceans, to ecoregions, to forests, farms, and ponds. Dr. Rowe described the ecosystem approach in terms of cooperating, adapting, and acting *from within* the ecosphere, and within the nested set of ecosystems. By operating as organisms living within this hierarchy of ecosystems, rather than as managers engineering change in an external 'environment', we stand a greater chance of achieving harmony and sustainability. All social and economic activities are part of the ecosystem hierarchy; they are not separate.

In the workshop discussions, "ecosystem approach" was understood to refer to the much broader, institutional or "political" definition presented in the preceding examples. While an ecosystem approach to science forms an important foundation for this much broader "ecosystem approach," it was recognized that science is only one influence on management and decision making. Socioeconomic factors and institutional arrangements are equally important considerations for environmental management.

1.3 Workshop Objectives

The main focus of the workshop was the development of ecosystem goals and objectives. As the United Nations Economic Commission for Europe states, the "...shift from setting pollution reduction targets to more comprehensive objectives characterizing the health [or so-called ecological integrity] of the ecosystem is a notable feature of the ecosystems approach" (UN 1991, p. 5).

The workshop had the following objectives:

1. To convey the value of the ecosystem approach, through conceptual overviews, case study presentations, and working group discussions.

2. To use the Fraser River Basin to create a process for setting ecosystem goals and objectives.

3. To develop some creative strategies for applying an ecosystem approach in different ecosystems.

4. To increase our understanding of the linkages between ecological and human systems.

5. To develop recommendations as to how people and institutions can work together to implement an ecosystem approach.

1.4 Workshop Structure

There were two overall themes to the workshop: setting ecosystem goals and objectives and developing implementation strategies and tools. These themes were explored by both plenary session presentations and working group discussions, as shown in the workshop agenda (Table 1).

Several leading practioners in the application of the ecosystem approach to terrestrial, surface water, and marine ecosystems attended the workshop. These experts gave presentations in the morning plenary sessions, and were available as resources to the afternoon working group sessions.

Table 1 Ecosystem Objectives Workshop, Dec. 7-9, 1992: Final Agenda

Monday - December 7th	Tuesday - December 8th	Wednesday - December 9th
8:30 a.m. Workshop Welcome [Gerry Armstrong]	*8:30 a.m.* **Summary of First Working Group Session**	*8:30 a.m.* **Summary of 2nd Working Group Session**
8:40 a.m. Review of Workshop Objectives & Agenda [David Marmorek]		
Presentation Session 1: The Ecosystem Approach *8:55 a.m.* Future Directions in Environmental Management [Pat Pender, Jon O'Riordan, Philip Halkett, Ed Wiken] *9:20 a.m.* The Ecosystem Approach: A Terrestrial Perspective [Stan Rowe] *9:50 a.m.* The Ecosystem Approach: An Aquatic Perspective [David Rapport]	**Presentation Session 3: Strategies and Tools for Implementation of Ecosystem Goals and Objectives** *9:30 a.m.* Freshwater Ecosystems (Ohio): Case 4 [Chris Yoder] *9:55 a.m.* Near Coastal Ecosystems EMAP-NC): Case 5 [Steve Weisberg]	
10:20 a.m. BREAK	*10:20 a.m.* BREAK	*10:10 a.m.* BREAK
Presentation Session 2: Setting Ecosystem Goals and Objectives *10:35 a.m.* Need for an Ecosystem Approach in the Fraser Basin [Tony Dorcey] *11:00 a.m.* Terrestrial Ecosystems (National Parks): Case 1 [Stephen Woodley] *11:25 a.m.* Near Coastal Ecosystems (Puget Sound): Case 2 [Nancy McKay] *11:50 a.m.* General Discussion	**Presentation Session 3 cont'd** *10:35 a.m.* Terrestrial Ecosystems (Forest Ecosystems Objectives): Case 6 [Andy MacKinnon & Ralph Archibald] *11:00 a.m.* Landscape Level: (Fisheries-Forestry Interactions): Case 7 [Steve Chatwin] *11:25 a.m.* General Discussion *11:40 a.m.* Charge to Subgroups [Marmorek]	**Wrap-up Session** *10:25 a.m.* Future Directions [Vic Niemela, John Azar, Jim McCracken] *10:40 a.m.* Discussion / Open Forum *11:40 a.m.* Closing Remarks [Vic Niemela]
12 noon LUNCH	*12 noon* LUNCH	*12 noon* LUNCH
1:00 p.m. Freshwater Ecosystems (Great Lakes): Case 3 [Trefor Reynoldson and Victoria Harris] *1:40 p.m.* Charge to Subgroups [Marmorek] *2:00 p.m.* **Subgroup Session #1: Setting Ecosystem Goals and Objectives for the Fraser River Basin** (7 groups: 1 landscape, 2 near coastal, 2 terrestrial and 2 fresh water) *4:30 p.m.* Adjourn for Day *6:00-8:00 p.m.* Dinner *8:15 p.m.* Adapting Institutions to the Ecosystem Approach [Jack Vallentyne]	*1:00 p.m.* **Subgroup Session #2: Implementing Ecosystem Goals and Objectives in the Fraser River Basin** (7 groups) *4:30 p.m.* Adjourn for Day *6:00-8:00 p.m.* Dinner	-- informal meetings --

1.5 Organization of this Report

The report is organized into six sections. Sections 2 through 4 are summaries of the workshop presentation sessions, and Sections 5 and 6 are overviews of the working group sessions. Stan Rowe and Victoria Harris provided summaries of their presentations; all other presentations have been summarized by ESSA staff from notes taken during the workshop. Section 2 provides a context for the detailed case studies which follow. It begins with a description of the possible future directions of provincial and federal environmental and resource management agencies. This is followed by descriptions of the general philosophy and practice of the ecosystem approach. Section 3 summarizes several case studies of the process of *setting* ecosystem goals and objectives. Section 4 describes strategies and tools for *implementing* ecosystem goals and objectives. The results of the discussions of the working groups are synthesized in Section 5. We conclude in Section 6 with a discussion of challenges and opportunities, and some parting thoughts from both the sponsoring institutions and workshop participants. The participants' feedback was acquired partly through a workshop evaluation form.

2.0 The Ecosystem Approach

2.1 Future Directions in Environmental Management[1]

Gerry Armstrong *Deputy Minister, Ministry of Environment, Lands and Parks*

- The ecosystem approach is becoming a preferred way of looking at environmental and social issues because it provides a unified framework and transcends traditional political and disciplinary boundaries. While this broadened framework will result in better-informed decision making, it requires a greater sharing of information and data.

- Although these issues are complementary to the spectrum of environmental management approaches, there is currently an institutional vacuum for such a framework.

- The Commission on Resources and Environment (CORE), the Fraser River Action Plan (FRAP) and the Protected Areas Strategy (PAS) are all test beds for the ecosystem approach. The B.C. State of Environment report was also developed from an ecosystem perspective.

- We now need to focus on the next steps, taking these ideas beyond individual initiatives and integrating them across the board.

Philip Halkett *Deputy Minister, Ministry of Forests*

- At UBC in the early 60's and 70's, biologists started talking about ecosystems. It has taken the last 20 years for this term to find its way into the vocabulary of the general public and into the lexicon and jargon of resource managers. It will probably take another 10-20 years for there to be broad understanding of what the concept really means.

- The public, resource managers, and politicians must all understand the implications of applying an ecosystem approach to environmental and social issues.

- The Forest Service is wrestling with the ecosystem approach because it has the difficult job of acting both as an environmental and a development agency.

- If the ecosystem approach is understood and implemented now, then we will be satisfied with resource management fifteen years from now.

[1] This section was summarized by Carol Murray.

Pat Pender   *Director General, Atmosphere Environment Service, Environment Canada*

- Forging partnerships between various non-governmental organizations (NGOs) and government agencies will allow us to coordinate activities and set goals effectively.

- Our management capacity is limited by our inability to predict changes. Consequently, we must make a greater commitment to environmental monitoring.

- FRAP provides an excellent opportunity to work together to monitor the environment and to create a sustainable development program. Central to this is the development of ecosystem objectives and long-term indicators for determining whether these objectives have been met.

- We must learn from the examples of others and we must remain flexible and creative enough to develop our own innovative approaches.

Jon O'Riordan   *Assistant Deputy Minister, Environmental Management Department, Ministry of Environment, Lands and Parks*

- We should not pretend that we are designing "ecosystem management". Any comprehensive management program must examine how human systems interact with the natural system.

- We face a number of challenges:

  1) A lack of trust by the public. For example, the fact that we only came to understand the CFC problem in last the 15 years has left the public wondering how well science can really inform us about environmental problems. Similar public scepticism exists over current pulp mill regulations and the health effects of killing gypsy moths.

  2) Monitoring efforts are often duplicated. Because it is difficult for one agency to give up turf, both federal and provincial agencies are collecting the same information. This wastes time, money and effort.

  3) Obtaining funding. Rather than obtaining new funds, we may need to reallocate existing funds in a more meaningful way.

Ed Wiken   *Managing Director, State of the Environment Reporting, Environment Canada*

- The ecosystem approach is inherent in the principles, context, and perspective of the Green Plan, which incorporates environmental, social, and economic elements into its definition of an ecosystem.

- The ecosystem perspective is interdisciplinary and holistic, recognizing the interconnections among ecosystem components. It can be adapted to specific spatial and time scales, and it acknowledges that people are a part of ecosystems.

- In order to fully incorporate these ideas into the decision-making process, we must move away from the reductionism that is inherent in current management. Existing agencies have narrow mandates, and necessary management links are missing. There are cultural barriers and skill deficiencies to overcome.

- Nevertheless, important changes have been made. Years ago, ecosystems drew the most interest at the technical level. Now, on the other hand, the ecosystem approach has been incorporated into several broad-based conferences.

- At the Environment Canada managers conference (which included 350 managers from across the country), human resources, equity, and other ecosystem resources were on the agenda.

- A transition team is trying to resolve environmental issues using an ecosystem approach across the three satellite groups of AES, Parks, and Conservation within Environment Canada.

- At the first Environment Canada Science Forum, ecosystem management (including the recognition of a need for sustainability, monitoring, and research) was ranked as the third highest issue, after population growth and consumption.

Future Directions in Environmental Management
Summary

- CORE, FRAP and PAS are test beds for implementing the ecosystem approach.
- The ecosystem approach transcends traditional political and disciplinary boundaries.
- We should forge partnerships between NGOs and government agencies.
- We must overcome public mistrust, duplication of effort, shortage of funds, and the reductionism inherent in current management approaches.
- Recent Environment Canada conferences have addressed issues related to the ecosystem approach.

2.2 The Philosophy of an Ecosystem Approach

Stan Rowe Professor Emeritus, University of Saskatchewan

The focus of this workshop is the better management of Earth-surface resources by using an ecosystem approach that recognizes the interrelatedness of land and water systems. Importantly, the idea of ecosystems as inherently valuable entities suggests that their welfare ought to be an end, rather than an approach, to problem solving.

Ecosystems as Volumetric Chunks of Earth Space

Just as the "scientific approach" exists because of a prior conception of science, so the "ecosystem approach" takes its meaning from a prior conception of an ecosystem. Is "ecosystem" merely an abstract concept or is it a real live thing? The answer makes a great deal of difference. This is what Tansley (1935) wrote in originating the term:

> Though the organisms may claim our primary interest, *when we are trying to think fundamentally*, we cannot separate them from their spatial environment with which they form one physical system. It is the systems so formed which from the point of view of the ecologist are the basic units of nature on the face of the earth.

Note two important points: 1) fundamental thinking tells us that organisms, ourselves included, cannot be separated from their Earth-matrixes with which, all together, they form integrated ecosystems; and 2) these "basic units of nature", are located on the face of the earth, as substantial volumetric objects. Tansley thought of ecosystems as a category of intermediate size, somewhere between atoms and the universe. It seems to me that use of the term *generically*, for Earth-systems of *all* sizes, has the advantage of suggesting the functional similarity of whatever subdivisions of the Ecosphere people choose to define and study.

Biological Bias Against Objectifying "Ecosystem"

The public in its innocence has no difficulty accepting that an ecosystem can be a real spatial object: a complete watershed, a lake with everything that is in it, a tract of forestland including its interpenetrating soil and air, or a river system. Academics have been more wary. Trained as biologists, many have strenuously resisted adopting the idea that an ecosystem can be anything more than an abstract concept, a textbook diagram with arrows showing energy flowing and materials cycling from box to box, lacking spatial dimensions and structureless save for compositional numbers pinned on it. They understand ecosystems primarily as a learning device whose chief value is the reminder that all organisms require the support of peripheral things.

Professional biologists came to the idea of "ecosystem" at the end of many decades of studying *organisms* as individuals, populations and communities. Committed by training to concepts of organisms, they attempted to incorporate the novel idea of "ecosystem" by simply adding to their familiar aggregations of organisms a nebulous "environment" usually conceived -- in good reductionist style -- as a bundle of factors. Hence the text-book definition of ecosystem as community-plus-environment.

Use of the term "ecosystem" in the scientific literature illustrates the same concept-by-addition. Many researchers use "ecosystem" in the sense of biotic community plus undefined environment; others imply vegetation plus soil, or vegetation plus animal community plus soil, or total plant-and-animal community plus landform plus soil. Rarely, if ever, is the air-layer considered a vital component, presumably because it is mentioned neither by the Bible's Genesis story of creation nor by Aldo Leopold when he defined what he meant by the "biotic community" or "land community". Yet surely the air-layer, the carrier of essential gases and nutrients, and the medium wherein climate is most vividly expressed, merits inclusion as an integral part of terrestrial and aquatic ecosystems.

Deriving "Ecosystem" by Subdivision of the Ecosphere

The dangers of trying to define holistic concepts by summing various identified parts, is exemplified by the well-known story of the academic Committee Report, each section written by a different author with no over-all direction. The result has been likened to piecing together a camel from the anatomical parts of a horse, unguided by a prior holistic equine idea.

Similarly, it is very difficult to define an ecosystem by studying its various components in isolation from each other, without an understanding of the "big picture". No one is likely to come to the concept of the inclusive watershed ecosystem by meticulously examining the forest stands within it. For example, years ago pedologists working in an arid part of Australia were confused by certain soils whose surface expression was a repetitive pattern of sandy ridges, clay flats, stony strips. A geomorphologist examined the soil maps and immediately recognized the patterns as an ancient floodplain. His prior understanding of floodplains as integrated systems of channels, levees, backswamps, point bars, and islands allowed him to understand the pattern of soils as *parts* of the larger unity.

Thanks to satellite photographs we have seen the whole of the Blue Planet and are now able to conceptualize it as an integrated ecosystem: the ecosphere, a giant blue-and-white cell floating in black space, on which we are totally dependent. How then shall we divide or stratify the ecosphere for purposes of study and ministration?

The old way was to isolate organisms which we said were "alive". All the rest -- water, air, landform, soils -- was "abiotic", dead material. Alternatively, we have divided the ecosphere into layers -- atmosphere, hydrosphere, lithosphere -- plus a category for all organisms, the biosphere. Neither division assists in understanding global problems such as climatic change, because all parts co-evolved in an inter-related way during 4.6 billion years of natural experimentation.

If the ecosphere is accepted as *the* important material entity in which we are immersed and at whose phase boundaries -- air, water, soil -- we live, then the most reasonable way to subdivide it for human comprehension is by imaginary vertical boundaries yielding chunks of earth-space, "units of nature on the face of the earth", to use Tansley's original phraseology. So understood, aquatic ecosystems are like giant aquariums and terrestrial ecosystems are like giant terrariums, with boundaries set at scales according to our purposes, each a complete piece of the Ecosphere in its possession of atmosphere, soil or sediments, water, and *organisms*, the latter *sharing importance* with the other constituents. In addition to organic indictors then, an entirely new set of "abiotic" structural/compositional characteristics and functions -- of landform, local climate, soils, and sediments, of the processes of erosion, energy dissipation, and resiliency -- can be used for the diagnosis of health and integrity.

The definition of ecosystems as spatial geographic units, variable in size depending on our purposes, lets us understand the concept of the world around us as ecosystems within ecosystems, from the large to the small, like Russian dolls that fit inside one another. The ecosphere is the largest system of immediate interest and nested within it are the three-dimensional ecosystems that we distinguish when describing or studying oceans and continents. Within the continents, *zonal* and *regional ecosystems* constitute a lower set of systems (such as the *ecoregions* recently defined for Canada and the USA) while still lower are *local ecosystems*: a forest, a farm, or a pond. If we want to understand how any given system works or how it functions, we look to the systems within it at a lower level of organization. If we want to understand the niche or purpose of any given system, we look to its role in the larger systems above.

Managing Ecosystems from the Inside

The holistic idea of ecosystems as chunks of Earth-space, ourselves inside them, casts a shadow of uncertainty over the Western cultural ideas of supervision and control. Can we "manage" Gaia, the planetary Being, this great entity in whose insides we dwell like an intelligent strain of *E. coli*?

The concept "environment" offered us a handy escape from the reality of our milieu because by definition, "environment" is outside us. By so conceiving our surroundings we were able to remove ourselves from the enveloping ecosphere. Separated in thought from the life-supporting milieu, we could in good conscience engineer and change its various parts: the surficial landforms and waterforms, the crustal rocks and minerals, the soils, the watersheds and airsheds, the millions of different kinds of organisms in their various populations and communities. The environment was seen as grist for our economic mills.

In contrast, by applying the ecosystem concept to the planet and realistically conceiving its volumetric sectors as the milieu of all organisms including people, we see ourselves transformed from God-like directors *outside* to potentially cooperative, though fumbling, components *inside*. The message for managers is "go slow and take care".

Some Conclusions

1. The "ecosystem idea" and "ecosystem approach" are not just pop phrases that, like "sustainable development", will be gone next year. They stand for substantial concepts and activities that bring a new focus to the people/nature relationship. An ecosystem is an integrative entity that produces an array of natural resources.

2. Although the idea of ecosystems as a volumetric component of the ecosphere is gaining ground, it is not yet universally accepted. The outside "environmental" view is expressed, for example, in B.C.'s "Land Use Strategy" (the Commission on Resources and Environment, Draft Land Use Charter): "The Province shall maintain and enhance the life-supporting capacity of air, water, land, *and ecosystems.*" Note that air, water, and land are specifically named as things other than "ecosystems," which translates the latter into biotic communities of B.C. Here the writers have picked up the jargon, incorporating "ecosystem" into their vocabulary, while still thinking in terms of a fragmented "environment."

3. As units of Earth-space, ecosystems are place-specific, definable and mappable at scales appropriate to land/water use interests. Boundaries are pictured as vertical walls purposely dividing the Ecosphere continuum. We need sensitive regionalizations such as maps and geographic information systems to distinguish between the various kinds of ecosystems. Geomorphic divisions (landtypes) scaled to our purpose give a good first approximation.

4. Conceived as Earth-space units, ecosystems are nested within the Ecosphere. Local ecosystems are nested within regional ecosystems. Each local ecosystem can be studied as an entity, but as part of the larger complex, it must also be related to the regional system that surrounds it (its ecology). A riverine ecosystem has its own particular morphology and

physiology, but it is also intimately related ecologically to the pattern of upland ecosystems; the totality is a watershed whole. The idea of sustainability is meaningless at the level of the local ecosystem -- a single farm, a single forest stand, a single reach of a river. Sustainability only makes sense at the regional level, involving the whole mosaic of dynamic, local ecosystems.

5. Wise use of ecosystems is difficult because:

    1) Ecosystems are complex and dynamic. Few commitments of money and personnel have been made to the delineation and structural-functional study of landscape and waterscape ecosystems within their regional settings. For example, in forest-dependent British Columbia, few studies of forest ecosystem succession have been funded.

    2) Institutional arrangements are inadequate. The departmentalized structure of universities and governments perpetuates the fragmentation of knowledge with a concentration on specific resources rather than on ecosystem wholes. New arrangements are needed for the study, conservation, and administration of ecosystems.

6. The concepts of ecosystem health and integrity are value-laden and must therefore be worked out in terms of both scientific understanding and human sensibilities, region by region. Some experience can be transferred from place to place, but where the human element varies the concepts of health and integrity will also vary. Thus, the experience of using the ecosystem approach in the Great Lakes region cannot simply be transposed to solution of problems in the Fraser Valley.

The Philosophy of an Ecosystem Approach
Summary

- Organisms, ourselves included, cannot be separated from their Earth-matrixes with which, all together, they form integrated ecosystems.
- We can divide the ecosphere by imagining vertical boundaries that create "units of nature on the face of the earth".
- We need maps and geographic information systems to distinguish between and increase our understanding of ecosystems.
- Sustainability can only be understood at a regional level, incorporating the whole mosaic of dynamic and local ecosystems.
- Concepts of ecosystem health and integrity must be defined for each specific region.
- We need new institutional arrangements for the study, conservation, and administration of ecosystems.

2.3 Ecosystem Health in Practice[2]

David Rapport *Professor, University of Ottawa*

Ecosystem health is emerging as a new science. By incorporating the medical diagnostic approach from preventative medicine, the syndromes and signs of ill health can be recognized early enough to prevent any "fatality".

One of the underlying assumptions of the ecosystem health approach is that an ecosystem is an organism that can be treated. It is important to remember, however, that ecosystems are supra organisms, composed of many parts. Nevertheless, signs of ecosystem health and illness are evident.

Although each ecosystem has unique properties, ecosystems as a whole share a common response to stress. The ecosystem distress syndrome (EDS) is as worrisome as other syndromes in the health sciences. EDS is not localized, but affects large-scale ecosystems and includes a number of signs that are generically similar regardless of the source of stress.

There are few pristine ecosystems. Most have been subjected to centuries of human use. The following excerpt from a study of ecosystem health in a Finnish estuary in the north of the Gulf of Bothnia provides us with an idea of the complexity of ecosystem health and diagnosis:

> First the "patient history" - what has it been exposed to? There has been over 400 years of cultural stress. Early on, the land was cleared for agriculture, pits were dug to get at tar-like substances, irrigation schemes, hydro power and fishing all impacted the ecosystem. One can develop a table much like a patient's chart. The other part is what happened to the ecosystem over time. There was a massive fish kill, which coincided with the water turning clear. Since there are acid sulphide soils in the region, we can assume that the human disturbances caused acidification of the drainage waters. Now there are frequent fish kills. These are probably related to increased land disturbances, while taking into account the long lag periods. To understand the stress response, one has to look at the spatial/temporal picture. The salmon were the first to go, the river spawning whitefish soon after, and finally the last species when the effects trickled down to the estuary archipelago. There is a lot of uncertainty in fish stock data, the habitat change is easier to measure.

If we are to practice preventative medicine, we need to avoid a simplistic react-and-cure approach to signs of distress and breakdown. Rather, we can learn from clinical pathology, focusing on the pressures to ecosystem health and developing criteria to determine when enough is enough. We can also do fitness testing along the lines of the EPA monitoring approaches. This may allow us to see the first signs of cumulative stress impairment in time for us to do something about the causes.

The science of ecosystem health is new. There is a book now available, of that title, with Bob Costanza as editor. The first international conference on Ecosystem Health and Medicine will take place in Ottawa in the summer of 1994 with presentations ranging from ethics to science.

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[2] This section was summarized by Pille Bunnell and Karen Paulig.

Ecosystem Health in Practice
Summary

- Ecosystem health can use the tools of medical diagnosis to recognize the syndromes and signs of ill health.
- Generic responses to stress can be recognized in all ecosystems.
- Fitness testing along the lines of the EPA monitoring approach may allow us to identify and respond to cumulative stress impairment.

3.0 Setting Ecosystem Goals and Objectives

3.1 Need for an Ecosystem Approach in the Fraser Basin

Tony Dorcey Chairman, Fraser Basin Management Board[3]

The Fraser Basin is as large as Great Britain and contains many important natural and human systems. Over two-thirds of the B.C. population is located in the Basin, and much of the province's economic, cultural, and social activity takes place here. Nevertheless, it is still relatively undeveloped, which means we have a large and enviable array of opportunities. But management of the basin requires broad considerations of both human and ecological concerns. The real question is whether we will do what we know needs to be done. The Federal Green Plan (Fraser River Action Plan), provincial interests, and local governments are all calling for action on the river.

The Fraser Basin Management Agreement was signed in May 1992 with sustainable management in mind. This unique agreement was signed by 3 levels of government, including 46 local governments, and the First Nations. There is a management board consisting of 18 people, who represent 6 diverse interest groups. The goal of the board is spelled out in grand terms, with a mandate that covers a range of ecosystems and the human systems within them. The intent is to build management from the bottom up, based on local and regional perspectives, and to work on consensus-based decisions that are fostered by governments throughout the basin bringing stakeholders together. The Fraser Basin Management Agreement is a test bed for many of the ideas being examined in this conference.

The mandate of the board is large, but the staff of six is small. The mandate involves four main elements:

1. *Leadership* - the board is responsible for leading the way in changing public perceptions, attitudes, and values (including the adoption of an ecosystem approach), and in promoting local decision-making processes;

2. *Coordination* - the board will attempt to eliminate duplication within the Fraser basin, and promote cooperation to joint advantage among different groups;

3. *Prioritization* - the board will recommend budget priorities needed to achieve the goals of the Fraser Basin Management Agreement. It is important to point out that the board prioritizes activities, but does not provide a new source of funding;

4. *Audit* - the board, working with the public, will determine whether or not groups working within the basin have accomplished what they set out to do. Audit results will be published annually.

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[3] This section was summarized by David Bernard.

There are three challenges facing the implementation of an ecosystem approach to the management of the Fraser basin, and the board can help with each of them:

1. *Putting ecological values first - we have to go slowly to go fast.* We must change people's attitudes and values as we move from a technocentric to an ecocentric perspective. This calls for straight-forward communication and education in the schools and society. We must tread carefully with the public so as not to counter our efforts in moving forward. As we move toward sustainability tough decisions will need to be made, sometimes involving desperate communities that are being closed down. How are we going to deal with these situations? The board can help here through its leadership and coordination activities.

2. *New decision-making processes - from consultation to negotiation.* We must choose new indicators, and we must set objectives and standards for both socio-economic and ecological realms. This new territory transcends disciplines. Equally important is the process by which decisions are made. Clearly we will have to shift away from the old ways of decision making, which seldom involved the concerned parties to a new way that involves all stakeholders. Ecosystem objectives cannot be hatched in workshops of scientists and then delivered to the public. Use of shared decision making approaches is new territory. In this environment, what is the role of government? The board can help by providing leadership, coordination, catalyzing the dialogue, and by prioritizing activities within the basin.

3. *Need for practical results - the public wants action, not more studies.* Budgets are tight, and people are asking "why support this endeavour?" We will need to produce research and innovative management in a field that is emerging as a new science. Finding existing information is difficult, and assessing that information is even harder. A great deal of political judgement is needed to find a balance between the pragmatic needs of politicians and new research. The board can help steer activities toward practical results by serving to coordinate, prioritize, and audit the ongoing activities in the basin.

Need for an Ecosystem Approach in the Fraser Basin
Summary

- The Fraser Basin Management Agreement has created a management board with 18 representatives from government, aboriginal peoples, industry, labour, non-government environmental organizations and the general public.

- The board provides leadership, coordination, prioritization and an audit function of the ongoing activities in the area.

- The board can help implement the ecosystem approach through education, encouraging new decision making processes, and steering activities toward practical results.

3.2 Setting Ecosystem Goals and Objectives for Terrestrial Ecosystems

Stephen Woodley *Forest Ecologist, Canadian Parks Service*[4]

It is intellectually dishonest to claim that we can manage ecosystems. Instead of considering ourselves to be managers with access to ecosystem levers whose movement will translate into certain results, we should more humbly think of our actions as assisting ecosystems. Ecosystem goals are expressions of human expectations for an ecosystem.

Traditionally, there have been three lines of development of ecosystem goals (Figure 1). The utilitarian view focuses on resource extraction and the ecosystem as source of products and services. The romantic view sees humans as separate from nature and wilderness. The more recent ecosystem-based approach to goal setting recognizes that humanity is an integral part of most ecosystems, and a dominant force whose survival critically depends on the maintenance of ecosystem integrity, ecosystem health, and biodiversity.

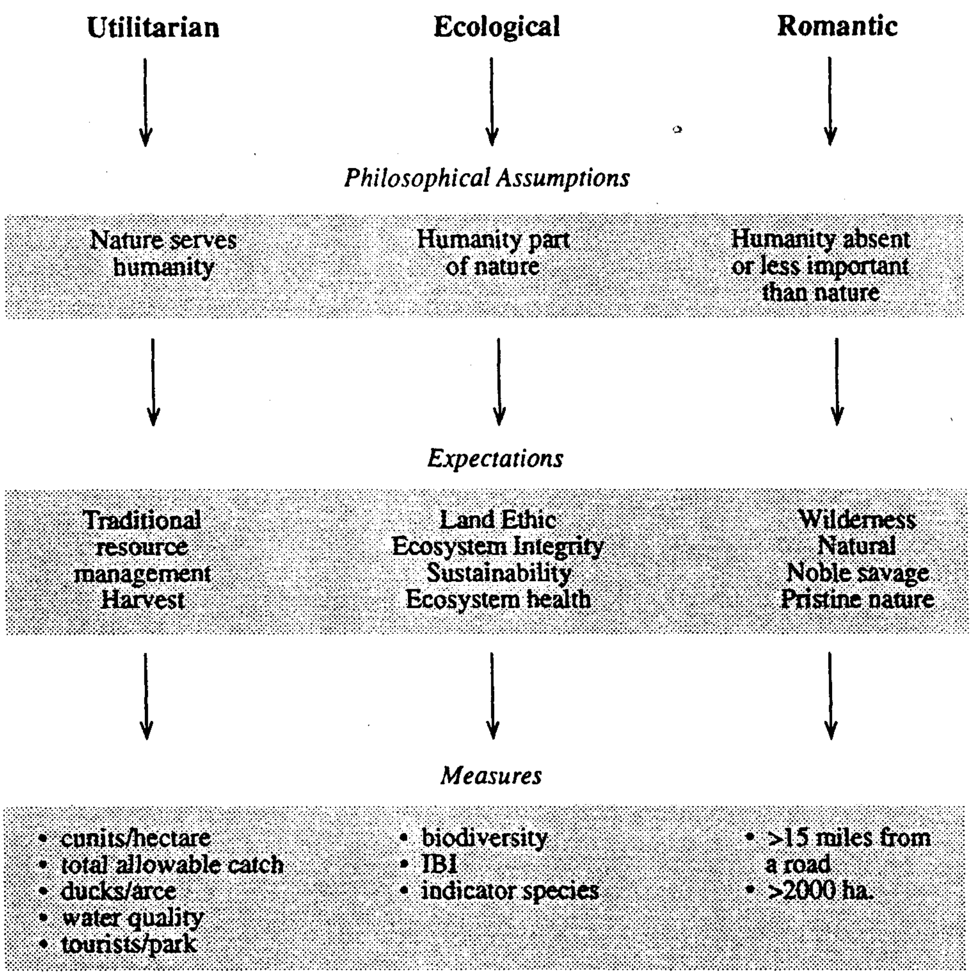

Figure 1 Three historical lineages in the development of ecosystem goals (from Woodley 1992).

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[4] This section was summarized by Werner Kurz.

Ecosystem science provides a valuable foundation for setting ecosystem goals. The hierarchical organization of ecosystems (cells, organisms, populations, communities, and landscapes) requires that the selected goals and indicators address all levels as well as the spatial and temporal components of the hierarchies. Not all indicators will respond equally, and whether or not changes in indicators are reason for concern will depend on the specific characteristics of ecosystems. For example, depending on bedrock geology, the export of a critical nutrient may be of concern in some ecosystems but not in others. In abused ecosystems nutrients leak and sizes decline.

Ecosystem goals must account for ecosystem structure and function. This requires a good understanding of ecosystem dynamics to evaluate whether or not deviations from the current conditions are acceptable. For example, periodic disturbances, such as wildfire, are an integral part of the terrestrial ecosystem dynamics in many parts of Canada. Catastrophic changes in an ecosystem state may have to be tolerated in some cases.

Ecosystem goals must be adaptable since ecosystem management is an experiment. In many cases, the current condition is the result of human-induced changes such as the transition from the wolf-caribou to the coyote-white tail deer system in Fundy National Park. A careful assessment of future changes should be considered when setting goals in stressed systems.

Definitions of ecosystem boundaries should accompany any ecosystem goals. Often, the boundaries of the system that is being managed have profound effects on ecosystem management. For example, it has been suggested that not one of the Canadian National Parks by itself is large enough to support a viable grizzly bear population though most parks could protect snowshoe hares. Areas smaller than 1000 km^2 are too small to protect mammal species.

Combining new technologies such as geographic information systems (GIS) with dynamic population models provides tools with which to explore the spatial and temporal aspects of ecosystem management. For example, present and anticipated future pine marten habitat can be displayed with GIS if the current forest ecosystem distribution and ecosystem dynamics are understood. With such tools, analyses of patchiness and fragmentation of habitat at various times in the future can be explored and compared against goals and objectives. Forest fragmentation can be seen to pose a serious risk to the maintenance of viable pine marten populations.

Ecosystem-based management promises to provide the tools for integrating humanity with the biosphere and for maintaining ecosystem integrity. The definition of specific and measurable ecosystem goals must be based on ecosystem science and society's priorities.

Work is in progress with a multi-stakeholder group in the context of the Fundy Model forest. The objective of the group is to use visioning exercises to come to agreement on relevant indicators. Alternative future forest conditions are explored (painting future landscapes) and the desirability of various conditions is determined (assigning values to the landscape). While the tasks are daunting and many remaining differences need to be worked out, the approach appears useful for any regional planning exercise.

Setting Ecosystem Goals and Objectives for Terrestrial Ecosystems Summary

- Selected goals and indicators must address all hierarchical levels in an ecosystem across space and time.
- Ecosystem goals should be adaptable and should take into account ecosystem structure and function.
- Geographic information systems and dynamic population models give us tools with which to explore the spatial and temporal aspects of ecosystem management.

3.3 Freshwater Ecosystems - Great Lakes

3.3.1 Developing Ecosystem Objectives and Indicators for the Great Lakes

Trefor Reynoldson *Environment Canada, National Water Research Institute, Burlington, Ontario*[5]

Under the Great Lakes Water Quality Agreement (GLWQA), the signing Parties (Canada and the United States) are required to develop ecosystem objectives and indicators for the Great Lakes. This acknowledges the need for broader and more integrative measurements than simply chemical-based water quality objectives to guide and evaluate management decisions. In early 1989, the Ecosystem Objectives Work Group (EOWG) was formed as an instrument for fulfilling that mandate. The EOWG defined ecosystem objectives as "a set of narrative statements that describe a desired state for attributes of the ecosystem" and indicators as "the variables, together with their target or reference values, that reflect the attributes of the objectives" (EOWG 1992).

The EOWG uses a two-staged approach to developing ecosystem objectives and indicators. The first step is largely political. All stakeholders are involved in a consensual process to construct a long-term vision for the state of the ecosystem. The outcome of this process is a set of major ecosystem goals. Technical input is required at this stage as a "reality check" to ensure that the elements of the vision are achievable, compatible, and sustainable. The next step is largely technical. The first task in this stage involves setting specific objectives that define desired characteristics for components of the ecosystem which are both necessary and sufficient for attaining the goals to be achieved. Appropriate indicators and numerical targets are selected on the basis of an expert review of both historic and current data (Bertram and Reynoldson 1992).

The EOWG focused its initial efforts on developing ecosystem objectives and indicators for Lake Ontario (objectives and indicators were developed in 1987 for Lake Superior as part of the 1987 revisions to the GLWQA). This process produced three goals and five objectives for Lake Ontario (Table 2). After developing these objectives, the EOWG formed six technical subcommittees to develop appropriate indicators for each of the objectives. These included indicators for: 1) benthic communities; 2) pelagic communities; 3) wildlife; 4) habitat; 5) human health; and 6) stewardship.

Benthos is often used as an indicator of sediment quality. Benthos are also important in food web processes and contaminant dynamics. Benthic organisms reside in or on the sediments, and tend to be short-lived (life cycles of one to a few years) and sessile. Their populations are also relatively stable under normal conditions. Furthermore, they are quick to respond to environmental changes and their response to such changes has been well-studied. All of these attributes make them ideal indicators of both sediment quality, and the implications of sediment quality for higher levels in the food chain.

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5 This section was summarized by Trent Berry.

Table 2 Ecosystem goals and objectives for Lake Ontario.

Ecosystem Goals
The Lake Ontario ecosystem should be maintained and, as necessary, restored or enhanced to support self-reproducing diverse biological communities.
The presence of contaminants shall not limit the use of fish, wildlife, and waters of the Lake Ontario basin by humans and shall not cause adverse health effects in plants and animals.
We as a society shall recognize our capacity to cause great changes in the ecosystem and we shall conduct our activities with responsible stewardship for the Lake Ontario basin.
Ecosystem Objectives
The waters of Lake Ontario shall support diverse healthy, reproducing, and self-sustaining communities in dynamic equilibrium, with an emphasis on native species.
The perpetuation of a healthy, diverse, and self-sustaining wildlife community that utilizes the lake for habitat and/or food shall be ensured by attaining and sustaining the waters, coastal wetlands, and upland habitats of the Lake Ontario basin in sufficient quality and quantity.
The waters, plants, and animals of Lake Ontario shall be free from contaminants and organisms resulting from human activities at levels that affect human health or aesthetic factors such as tainting odour and turbidity.
Lake Ontario offshore and nearshore zones and surrounding tributary, wetland, and upland habitats shall be of sufficient quality and quantity to support ecosystem objectives for health, productivity, and distribution of plants and animals in and adjacent to Lake Ontario.
Human activities and decisions shall embrace environmental ethics and a commitment to responsible stewardship.

As part of the EOWG subcommittee on benthic communities, Reynoldson and Zarull (1991) have developed an approach to setting numerical biological sediment objectives on the Detroit River. The approach uses both sediment bioassays (laboratory studies of the response of selected benthic organisms to a particular sediment sample) and *in situ* studies of benthic response (i.e. field observations of benthic community structure such as composition and numbers under certain conditions). The approach consists of four steps:

1) Reference communities are classified by using statistical techniques to determine the habitat characteristics (e.g. chemical and physical attributes of local environment) which best discriminate among different reference communities, each representing a pristine or less impaired state (i.e. little or no pollution or disturbance). Ideally, these variables would be minimally changed by pollution.

2) A model is developed to predict the biological community from sediment characteristics: The model predicts the type of communities expected at similar sites with little or no pollution or other human-caused impacts.

3) The model is applied to test sites (additional unpolluted communities); and

4) Impairment of polluted sites is determined through comparison of existing community structure with the community structure predicted by the validated model.

This approach could be applied to any type of environment for estimating ecological integrity and setting indicator targets. It is not meant to replace chemically-based approaches, but rather to complement such targets. The most critical factor for success, however, is identifying the appropriate environmental attributes to distinguish among different types of healthy communities and between healthy and unhealthy communities of each type.

3.3.2 Using the Ecosystem Approach in Remedial Action Planning for Lower Green Bay and the Fox River, Lake Michigan

Victoria A. Harris *Wisconsin Department of Natural Resources - Lake Michigan District, Green Bay, Wisconsin, USA*

Traditional management approaches have been inadequate to halt the environmental degradation of the Great Lakes (Francis et al. 1979). For example, over the course of ten years, a waste load allocation model was developed to address environmental concerns in the Lower Green Bay and Fox River area. Industry and government worked together to improve dissolved oxygen levels. It is estimated that $338 million was spent to implement the model by constructing or upgrading waste water improvement facilities. As a result, the biological oxygen demand was greatly reduced, improving the warm water fisheries. Ultimately, however, because the model only examined one small aspect of the problems facing the region, it failed to address other equally valid concerns. The fish have returned, but they are unsafe to eat because of the high level of PCBs and other toxic substances that remain in the water.

New models that adopt an ecosystem approach are now being developed. An ecosystem approach has been applied in the development and implementation of a Remedial Action Plan (RAP) for Lower Green Bay and the Fox River, Lake Michigan, Wisconsin, USA. The approach couples ecosystem science with resource management and stakeholder participation to restore beneficial uses of a Great Lakes Area of Concern. For example, the state of Wisconsin was successful in acquiring monitoring funds from industry via cooperative agreements.

A key to the recovery of ecosystem integrity (defined here as healthy function and structure) is the development of integrated management goals and objectives that are specified in functional terms. Objectives should reflect ecosystem structure and function at all relevant hierarchical levels. An Ecosystem Criteria Workshop in 1985 (Harris et al. 1987) and subsequent RAP technical advisory committees have identified meaningful indicators of ecosystem integrity which serve as operational guides for management of Green Bay or other ecosystems. Useful criteria for selecting indicators are listed in Table 3.

The development of ecosystem goals and objectives for the Lower Green Bay and the Fox River RAP is an iterative process, undergoing periodic refinement as new understanding of the ecosystem evolves. The first step in the objective-setting process was to document current use impairments in the system. A "Citizen's Desired Future State" and planning goals were then developed through extensive stakeholder consultation. Examples of ecosystem objectives, including numerical objectives for toxic substances, are listed in Table 4. Objectives have been developed for fish and benthic invertebrate community structure, population levels and densities of sensitive (indicator) species; integrated trophic state, water quality, and levels of toxic contaminants in various ecosystem components.

Table 3 Useful criteria for selecting indicators of ecosystem integrity.

1.	How important is the indicator for understanding the ecosystem?
2.	Does the indicator describe the important ecological and human use impairments?
3.	Is the indicator integrative and reinforcing?
4.	Is the indicator useful/practical for management?
5.	Is the indicator measurable/quantifiable?
6.	Is the indicator diagnostic and sensitive to ecosystem change over time and space?
7.	Is the indicator predictive?

The use of ecological risk assessment has also been employed to identify which stresses pose the greatest risk for the Green Bay ecosystem (Harris et al. 1993). The relative risk of key stresses for the Lower Green Bay were ranked from several perspectives including the present impact on beneficial use impairments, the length of time the impact will remain once the stress is removed, and the manageability of the impact. Using mathematical analyses (based on Fuzzy Set Theory) the relative ranking of ecosystem stresses indicated that stresses which have large impacts, are difficult to manage and result in irreversible changes in the ecosystem pose the greatest ecological risk. The ability to compare environmental risks will help set priorities and target resources for the most effective risk reduction strategies.

Some interesting conclusions from the Green Bay environmental risk assessment which may prove relevant to other systems:

- Stresses that have large long-term impacts, are difficult to manage and result in irreversible alteration of the ecosystem, pose the greatest risk (i.e. wetland/shoreland filling and exotic species).
- Stresses having the greatest present impacts on Green Bay are also the most manageable and relatively short-lived (e.g. phosphorus/suspended solids loading).
- Small-scale problems, when not addressed, can be magnified into large-scale problems at the ecosystem level.
- Relative risks may change as our understanding of the ecosystem evolves and will not be the same in different settings.
- The ability to compare environmental risks will help set priorities and target resources at the most effective risk reduction strategies.

Freshwater Ecosystems - Great Lakes
Summary

- After a series of public consultation meetings, the EOWG formed six technical subcommittees to develop appropriate indicators for each objective.
- The RAP for Lower Green Bay and Fox River, Lake Michigan couples ecosystem science with resource management and stakeholder participation.
- The development of ecosystem goals and objectives is an iterative process: goals and objectives are altered as new knowledge is acquired.
- The ability to compare environmental risks will help set priorities and target resources towards the most effective risk reduction strategies.

Table 4 Examples of biological, water quality and toxic substance objectives for lower Green Bay and the Fox River

Biological Objectives			
Objective	**Annual Population**	**Population Density**	**Comments**
Maintain Forester's Terns (AOC and west shore)	Average: 400-600 pairs Minimum: 50 nesting pairs	Produce 1 fledged chick/pair	• Endangered species • Minimum population numbers during high water levels
Diving Ducks	Average: 2 million duck use days in AOC and along west shore		• Objective is twice use observed in 1978
Maintain diversity of marsh nest birds		Minimum: 15 nesting pairs/acre habitat	• Habitat is persistent emergents • Currently 14 species
Maintain emergent wetlands	Minimum: 2272 acres low-water and 384 acres high-water in west shore zone		• Area to be revised based on new wetland inventories
Yellow Perch	Minimum: 5 age classes	Average: 2000 yearlings or older per trawl hour (August index surveys)	• Population maintained through harvest quotas and refuges
Shift fishery biomass to increased predatory species	Predator/prey ratio range: 1/10 to 1/20	200-300 lb. predator and sport fish/acre	• Reflects greater food chain efficiency
Protect against sea lamprey infestation	No sea lamprey above Rapid Croche Dam		• Barrier constructed at dam
Diverse community of pollution intolerant benthos		Hexagenia 400-500/m^2 F. clams 500-1000/m^2 Snails 250-500/m^2 Mayflies 250-500/m^2	• Based on 1939 observations for silt-silty sand substrates

Water Quality			
Objective	**Concentration/Level**	**Where and When**	**Comments**
Water Clarity	Average: 1.3 m secchi disk	AOC during summer	• Clarity needed for safe swimming & to re-establish submerged aquatic plants
Reduce suspended solids loads by 50%	Average: 10 mg/l	Lower Bay, summer	• Current levels are 20-35 mg/l and 83 million kg per year
Reduce algae	Average: 25-35 μg/l	Lower Bay, summer	• Reduced frequency and biomass of blue-green algae
Reduce total phosphorus loads by 50%	Average Conc.: 90 μg/l	Lower Bay, summer	• Current levels are 147 μg/l and 12.5 g/m^2/year

Examples of Numerical Objectives for Toxic Substances						
Media	**PCB**	**Dioxin**	**DDT & Metabolites**	**Ammonia**	**Mercury**	**Lead**
Water Column Objectives for:						
Human Health (Human Cancer Criteria)	0.15 ng/l	2,3,7,8-TCDD 3×10^{-5} ng/l	4,4'-DDT 0.043 ng/l	NA	79 ng/l	5×10^{4} ng/l
Human Health (Proposed Great Lakes Initiative)	0.003 ng/l	2,3,7,8-TCDD 1×10^{-5} ng/l	4,4'-DDT 0.06 ng/l	NA	2.0 ng/l	Not presently available
Fish Tissue Objectives for:						
Human Health (Consumption fish filets)	FDA 2.0×10^{3} μg/kg	0.01 μg/kg	5×10^{3} μg/kg	NA	DNR 500 μg/kg	NA
Wildlife Health (Consumption whole fish)	23 μg/kg	7.7×10^{4} μg/kg	1.3 μg/kg	NA	14 μg/kg	NA

3.4 Near Coastal Ecosystems - Puget Sound[6]

Nancy McKay *Executive Director, Puget Sound Water Quality Authority*

In 1985 the Puget Sound Water Quality Authority was formed, and assigned by state legislature to come up with a comprehensive plan (called the Puget Sound Water Quality Management Plan) to protect the biological integrity, including the health and diversity, of Puget Sound in the face of growing population pressures.

The Authority aims to preserve and restore wetlands and aquatic habitats, prevent increases in the introduction of pollutants to the Sound and its watersheds, and reduce and ultimately eliminate the entry of pollutants to the waters, sediments, and shorelines of Puget Sound. Specific goals are also identified for a number of programs under the plan: Municipal and Industrial Discharges, Contaminated Sediments and Dredging, Spill Prevention and Response, Stormwater, Non-point Source Pollution, Shellfish Protection, Wetlands Protection, Research, Monitoring, Education, and Public Involvement. For example, the goal of the Spill Prevention and Response Program is to emphasize spill prevention strategies and enhance response capability in Puget Sound and its tributaries, and to ensure that the actions of state agencies are coordinated among themselves and with federal, local, tribal, and private efforts.

The Authority is made up of 11 people who serve as volunteers and meet monthly. Some of these people have been involved since the beginning seven years ago. Some members represent specific constituencies, including cities, counties, tribes, the Department of Ecology, and state lands. Others members represent a cross-section of citizens in the area. The plan is currently on a four-year cycle for revisions.

This project could not -- and will not -- be successful without the support and involvement of the public. To carry out the Authority's mandate, specific public involvement criteria are followed for every plan, rule and program. Stakeholders were involved from the beginning of the project, and the identification of new stakeholders is an on-going process. Issue papers (on both legislative and stakeholder issues) were produced, and the public was given the opportunity to respond. Plan development followed, with heavy public involvement. This took 18 months, and continues through ongoing adaptations to the plan. Public involvement and the political will to tackle the issues has helped the plan grow to the point where there is now $37 million for implementation.

Monitoring the stresses and degradation -- as well as background monitoring -- is part of the plan, and is a success story of interagency cooperation. If monitoring efforts were jointly operated with different protocols it would be impossible to obtain a comprehensive picture. Instead, the project is using one common GIS which all agencies contribute to but only one agency runs. The results are translated into information that decision makers can use. It requires 75% of the funding for the entire project to support the monitoring program.

Education and stewardship are cornerstones of the plan. Many of the education programs involve peers teaching peers, and schoolchildren teaching parents. The State Board of Education

[6] This section was summarized by Carol Murray.

now requires that every curriculum from kindergarten through to grade 12 include environmental education.

To provide legislative clout, a Growth Management Act has been passed by legislature. It requires most counties to develop a comprehensive land use plan incorporating the goals of the Authority, in order to turn these goals into actions that make a difference.

It is difficult to determine the success of the Authority's work. Stemming the tide of dramatic wetlands loss continues to present a challenge, and shellfish beds are still being closed due to contamination. There are some particular success stories, however, but there are still major challenges to face: keeping the public involved, fostering effective communication, finding funding, and deciding on priorities.

Near Coastal Ecosystems - Puget Sound
Summary

- The Puget Sound Water Quality Authority was formed to protect the biological integrity, health and diversity of Puget Sound.
- Public involvement is integral to every plan, rule, and program.
- Agencies share a common geographic information system to monitor stresses and degradation.
- Education and stewardship are cornerstones of the plan. The State Board of Education now requires that every curriculum from kindergarten to grade 12 include environmental education.
- To provide legislative clout, a Growth Management Act has been passed by legislature that requires most counties to develop a comprehensive land use plan incorporating the goals of the Authority.
- The main challenges are keeping the public involved, fostering effective communication, finding funding, and deciding on priorities.

3.5 Adapting Institutions to the Ecosystem Approach[7]

Jack Vallentyne *Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, Ontario*

imagery:

A bottle of whisky is produced, and confirmed to be the "real thing" by the chairperson. Glasses are filled to represent population growth. On the left is a glass with a finger of whisky in the bottom. The next one is double, then double again, and the fourth on the right is filled to the brim. The audience watches, entranced. Jack explains that he is going to drink the first one now, and the next ones in a timed progression through his talk. He asks the audience to time the intervals,

[7] This section was summarized by Pille Bunnell and Karen Paulig.

and tell him when to drink the next one. The laughter of the audience is incredulous, nervous, and amused.

The ecosystem is the interaction between living and non-living. Life does not exist alone. "Life" and "environment" are both abstractions. In reality, they are inseparable.

In 1978, as a result of transboundary issues, a report was submitted to the IJC (International Joint Commission) that recommended an ecosystem approach to planning. This approach took into account people and the environment, and it focused on health issues. When this report was presented, the speaker used the whisky imagery that I am using now. Leaders of industry say that growth is a good thing. But like whisky in the body, growth has a natural limit.

The ecosystem approach was accepted by the IJC for four reasons. The first was the impact of the whisky demonstration. The second was a study on pollution from land-use activities (i.e. the discovery of the extent of pollution from non-point sources). The third was the declaration that the Love Canal was hazardous to human health. The fourth reason the IJC adopted the ecosystem approach was that the senior deputy minister at the time refused to sign the re-negotiated agreement unless this approach was incorporated.

Time is called and the second glass is emptied. The audience realizes that this might be for real - the laughs are a bit edged.

Our ways of looking at the world tend to separate the environment into its social, economic and biophysical components. The ecosystem approach attempts to unite these components. For example, a rebel group of economists who have broken away from the dogma that economics is independent are setting up "ecological economics".

It is important to:

- know your ecosystem;
- be holistic, know you are in it;
- consider ecosystem behaviour - be anticipatory; and
- remain ethical with respect to the ecosystem.

There are two different types of causations in dealing with ecosystems. The first is upward causation, where you think cause precedes effect. However, when you get past the inflection point, downward causation comes into play. The boundaries become the active "causatory" elements. Constraints are perceived on our thinking and acting. In this century we have gone past the inflection point, and we are having a very hard time coming to grips with the reality of the constraints. Human growth is not sustainable.

"This stuff is really getting to me." The speaker's ideas are starting to wander and he stumbles over some of his words.

Time is called again, somewhat gleefully. The third glass is downed, all in one shot - straight as if it were water. A slight flush spreads on Jack's face. There is laughter and some shuffling. Some people are concerned, while others think it's a trick. Everybody is waiting to see what will happen.

Substantial institutional change is needed to implement the ecosystem approach. Think of a cross with two arms. The vertical arm is the collection of different bodies, small (concerned citizens, public interest groups) to large (federal departments, international agencies). The horizontal arm is the various departments (atmosphere, municipal waste water, recreation, hazardous wastes, etc.) that are involved. These groups are supposed to interact, but the linear structure prevents this from happening. The departments that are supposed to help are really barriers. In an ecosystem approach the groups and departments should be in a circle, with doors to the middle so that interaction is the focus. We need to reward and legitimatize interactions.

An ecosystem approach is a local and global connection that represents all the stakeholders in the system. The more local the involvement the better, because decision makers will have first-hand knowledge of the problems.

There has been an attempt to fit the environment into a political context, but we also need to fit politics into the ecosystem. Institutional rearrangements need to be developed to deal with this change in context. In the last five years, the ecosystem approach has been introduced in kindergarten. It is very important to bring the children into the system, in order to steer them in this direction. They are the 10-50 year projects.

There is a need for a closer relationship with the government. IJC members advise, but they do not represent government policies. There is no need for an international border for this sort of organization. The IJC participants come from both the U.S. and Canada and recommendations flow back to both countries. The B.C. government could set up a similar body.

Time is called again. Jack takes the full glass of whisky, and drinks it in one long draught. Ahhh. He wipes his mouth and his eyes flash as his soft voice accuses the audience:

> *"You bastards! You let me drink, knowing exactly what would happen, and you didn't stop me! Apathy, public apathy! That is significant. I've done this before and in most audiences someone tries to intervene. It's almost always a woman. A woman will stand up and say "stop it!". You guys are going to let me die! Go on with your business! Let me die, call an ambulance. Just like how we are treating our impact on the earth. Population growth..."*

There is a need to set up an agency with the authority to transcend politics. Anyone who serves the organization does so for defined times and defined problems. They serve in their professional and personal capacity rather than as an agent of the organization who employs them. People must not represent an agency if they are trying to represent the whole. That means that anyone on the task force who advocates a narrowly focused mandate is penalized, not listened to. The structure should also penalize non-interaction in order to encourage the active contribution of ideas that lead to change. There is no need for a Department of the Ecosystem. What we need is more interaction between the existing "body parts" of the government.

One of the best examples of the ecosystem approach was the Toronto Waterfront Study. David Crombie started expanding it, first along the foreshore, and then up the drainage. He was a pacesetter because he dealt with the issues by looking at them as a whole.

The whisky's effect is apparent - amazingly Jack is still on his feet, still coherent. The metaphor exemplifies the valiant efforts of the system trying to cope with pollution. Life force, will, whatever, is carrying on. How far?

The paradigm of ecosystem health necessitates a preventative approach. Did you know that in our health system 90% of expenditures are made in the last six months of life? Chlorine should have never been released. It is a very active chemical, with many insidious effects. When the ban on organochlorine insecticides was implemented in Israel, there was a drop in breast cancer. There are about 1500 naturally occurring organochlorines and almost all of them are used in biological warfare. Organochlorines in general are harmful. Recommended is a class ban - dechlorinate human society! This includes drinking water! Another problem is PVCs. If we have a house fire, large and uncontrollable quantities of dioxins and furans are released to the atmosphere.

How do we get leaders to change? We can't expect politicians to change their behaviour and attitudes unless a groundswell of public activity and opinion encourages them to do so. In a democracy, leaders are elected to represent the people and their interests. If people demand responsible behaviour towards the biosphere, leaders will change because their re-election depends on it.

Adapting Institutions to the Ecosystem Approach
Summary

- We must realize that human population growth is not sustainable.
- We need substantial institutional change in order to implement the ecosystem approach. We will have to encourage and reward interactions among various agencies.
- It is essential that we adopt an ecosystem approach to management.
- Political leaders will only change their actions if public opinion encourages them to do so.

4.0 Strategies and Tools for Implementation of Ecosystem Goals and Objectives

4.1 Setting Ecosystem Goals and Objectives for Forest Ecosystems[8]

Andy MacKinnon *Manager, Ecology Program, Research Branch, Ministry of Forests*

The idea of ecosystem objectives is rather presumptuous, given how little we know about ecosystem structure and function. However, despite this imperfect knowledge, forest ecosystems are being managed. Ecosystem goals and objectives should be defined, while recognizing that these are based on incomplete understanding and may have to be adjusted as the knowledge base improves.

An ecosystem approach means "that we shift our focus from parts to wholes, from interest to the capital, from trees and other plants, animals, stream flow to the three-dimensional landscape ecosystems that produce these valuable things" (Rowe 1992). The only possible basis for sustained use is to understand each tract of land and forest site in its regional context.

The following tools are available for an ecosystem management approach:

- mapping elements of ecosystem structure;
- models of ecosystem dynamics;
- experimental management techniques; and
- monitoring indicators of ecosystem health.

Ecosystem classification is one way of organizing knowledge, identifying knowledge gaps, and producing interpretations for managers. It also helps to promote the ecosystem as the basic unit of management. Several ecosystem classification systems exist in B.C. The Ministry of Forests uses the biogeoclimatic classification system, while the Ministry of Environment classifies the province into ecoregions. The two systems were developed for different uses and are complementary. Some uses require both systems.

The biogeoclimatic system is used for a large number of resource management issues, including timber, range, wildlife, and protected areas. It is the basis for integrated resource management, forest planning, and land use allocation. It is also used for site-level decisions of site preparation, silvicultural systems, and growth and yield. The general trend is away from an administratively-based area classification towards an ecosystem-based classification.

Ralph Archibald *Operations Manager, Integrated Resources Branch, Ministry of Forests*

The following is an example of applying the ecosystem approach to the management of the coastal forest at the landscape level. There are three driving forces for these activities:

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[8] This section was summarized by Werner Kurz.

- the legislative mandate of the Ministry of Forests, which is the stewardship of all forest resources;

- a recognition that status quo management is not meeting that mandate; and

- the public imperative to do things better.

These factors resulted in a group of managers and researchers getting together to develop a new paradigm and to address some of the resource concerns at the regional, subregional, landscape and stand level. The Commission on Resources and Environment (CORE) and other forest planning initiatives are addressing subregional issues, while the protected area strategy is addressing the regional level. Our group has been focusing on the stand and landscape levels.

In the new approach, the landscape is described as interconnected areas (such as watersheds) in units of five thousand to fifty thousand hectares. Our focus is to maintain ecosystem health and to manage it in a manner consistent with ecological theory (especially conservation biology), existing knowledge, and best judgement based on previous coastal management experience. We also recognize that any new system must be "user-friendly"; that is, the practitioners in the field must be prepared to use it.

Our basic assumption is that the habitat needs of most species will be met if we maintain all ecosystem types across the landscape. The landscape guidelines include two equally important components: the creation of a forest ecosystem network and prescriptions for the working forest. The forest ecosystem network is a series of linked reserves that are permanently withdrawn from forest harvesting (Figure 2). Reserve areas need to be mapped and linkages between them established. The objective is to ensure that all ecosystem types are represented in the protected reserves and that rare and endangered species are included in the protected areas. The linkages between reserves can be harvested, though only under severe constraints.

The resulting landscape consists of forest reserves, connections between the reserves, and a working forest. The prescriptions for the working forest will have to be developed to maintain habitat diversity. In this way, the guidelines explicitly address cutblock size, fragmentation, adjacency, and the proportion of different age classes allowed within the landscape.

The major advantage of the ecosystem management approach is that it provides us with a defensible management program that includes a map-based description of the current and anticipated future states. This approach simplifies the management process because it collapses a large number of guidelines for many different purposes into a smaller, comprehensible set. Conflicts among resource managers should be reduced because a shared vision is jointly developed and long-term production goals are agreed upon.

Monitoring the outcome of the prescriptions and the dynamics of the forest ecosystems under management will be an integral component to ensure the success of this approach. At present, our conceptual development is far ahead of our specific understanding and knowledge. It is therefore imperative that we test our assumptions, and that the results achieved with our prescriptions are compared against the anticipated results. Decisions have to be made in an adaptive management framework that includes monitoring a set of meaningful and relevant indicators. One of the current research needs is to define these indicators.

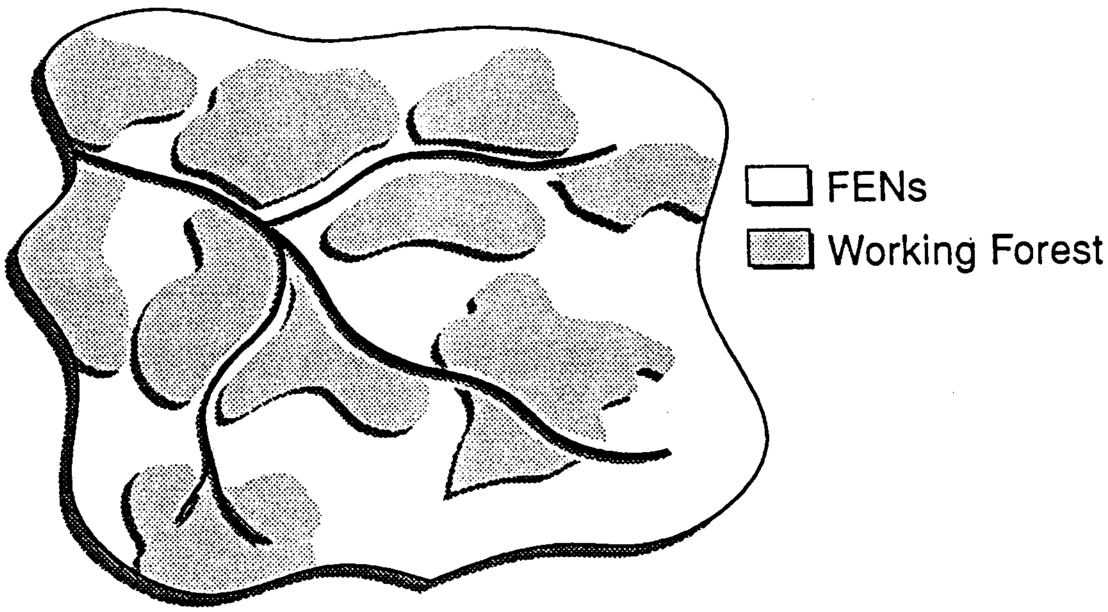

Figure 2 The forest ecosystem network (FEN) is a series of linked reserves. (Source: Archibald, Workshop presentation)

The overall intent of this approach is to improve our ability to maintain the ecological capital and to provide the interest to society.

Setting Ecosystem Goals and Objectives for Forest Ecosystems Summary
• Ecosystem classification -- such as the biogeoclimatic or ecoregion classification system -- encourages managers to use the ecosystem as the basic unit of integrated resource management, forest planning, and land use allocation. • The BC Ministry of Forests has attempted to maintain all ecosystem types across the landscape by creating a forest ecosystem network and formulating prescriptions for the working forest. • Monitoring the outcomes of the dynamics of forest ecosystems under management is integral to the success of the project.

4.2 Freshwater Ecosystems

4.2.1 Ohio Rivers[9]

Chris Yoder Manager, Ecological Assessment, Ohio EPA

Environmental baseline data should be collected just like weather data. Under the U.S. federal Clean Water Act, Ohio has gone from a *water quality* to a *water resource* perspective, moving from strictly physico-chemical to biological water quality criteria. To make this possible, we have had to adopt new tools for determining use attainment and assessing use attainability. Before the use of biological criteria and biosurveys went into widespread use, though, we had to convince people that biological monitoring was both cost effective (see Table 5) and that it provided us with useful information that we could not get from physico-chemical sampling (Figure 4).

Table 5 Comparison of the cost of ambient chemical, bioassay, and biosurvey assessment on an entity and stream survey evaluation basis, using cost data from Ohio EPA in FFY 1987 and 1988. This is based on an example that includes three point sources discharging to a medium-sized river in an urban and rural setting in Ohio. (Source: Yoder 1989)

Category	Chemical	Biosurvey	Bioassay
Samples	90	12	9
Unit cost sample	$360	$1,850	$1,850 (acute)[1]
			$3,050 (7-day)[2]
Survey cost	$32,400	$22,200	$16,650 (acute)[1]
			$27,450 (7-day)[2]

Source: The Cost of Biological Monitoring (Ohio Environmental Protection Agency 1990)
[1] 96-hour definitive test using *Cenodaphnia* and fathead minnow
[2] 7-day acute chronic test using a 24-hour composite sample

At the outset of this project, we needed to define "biological integrity". In Ohio, our environment has been disturbed over the past 200 years, so it was not possible to locate pristine environments. Consequently, we have had to rely on an operational definition of biological integrity (modified from Karr and Dudley, 1981): "*the ability of an aquatic community to support and maintain a structural and functional performance comparable to the natural habitats of a region.*" Biological data have a reputation of being highly variable. Thus, we looked for a way to compress the variability in a numeric rating scale of attributes, such as the Index of Biotic Integrity (IBI). In such an approach, reference sites are used to calibrate the index, which is then used to differentiate and evaluate sites. The biocriteria standard is set by the best condition in the area. Biocriteria can vary by ecoregion (Ohio has five) and stream-use classification. In this way we get a hierarchy of goals.

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[9] This section was summarized by David Bernard.

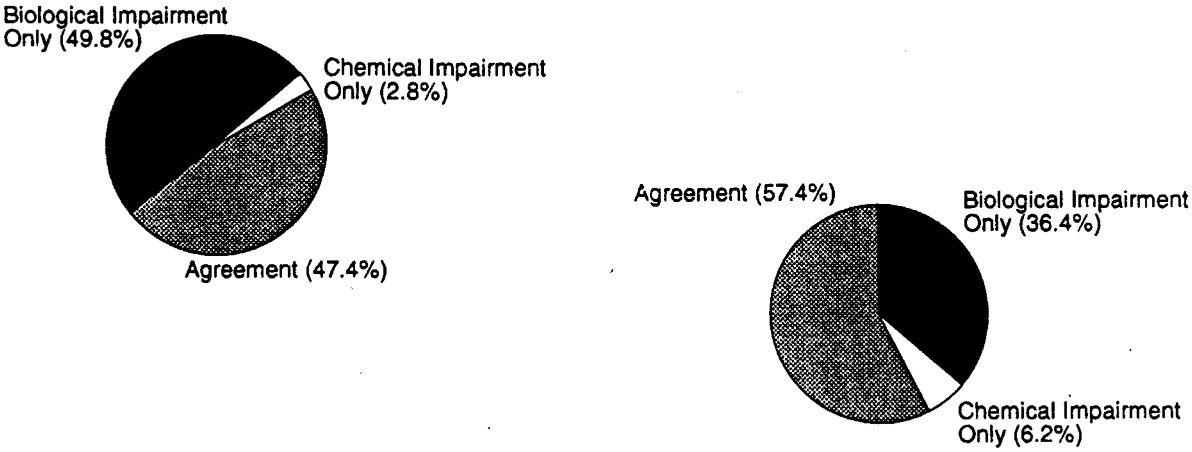

Figure 3 Comparison of the abilities of biocriteria and chemical criteria to detect impairment of aquatic life uses in 625 waterbody segments throughout Ohio. Data were based on chemical water quality criteria currently in Ohio's water quality standards (upper) and supplemented with nutrient data using threshold values from ecoregional analysis (lower). (Source: Yoder 1989).

As performed in Ohio, biosurveys are composed of three types of sampling: 1) *biological*: fish and invertebrates; 2) *chemical*: water column, sediment, fish tissue; and 3) *physical*: macrohabitat (QHEI), flow. Macroinvertebrates are sampled using standardized artificial substrates (six-week colonization to dampen out variability), indexed to season. We also take a qualitative, kick sample from the natural substrate. Samples are identified to the lowest possible taxonomic level, which is labour intensive in the lab. We also have a rich fish fauna (≈ 160 spp.). Fish are useful for showing sublethal stresses, such as external anomalies, and indicating locations where there is chronic toxicity stress. Fish sampling is labour intensive in the field, not the lab. Thus, costs for fish and invertebrates sampling are about the same.

How do biocriteria compare with chemical sampling? Our experience in Ohio shows that about 50% of the time we see biological impairment when there is no evidence of chemical impairment (Figure 3). About 3% of the time we see evidence of chemical impairment but no biological impairment. And about 47% of the time the evidence of impairment from biological and chemical sampling is in agreement. This strongly indicates that chemical sampling alone is inadequate.

We believe that routine biological and physico-chemical monitoring has to be part of the cost of doing business. For example, we plan water treatment facilities that will cost millions, but without monitoring we cannot determine their success. Biomonitoring can be used to show people what they bought for their sewage investment.

These methods could be applied to other jurisdictions, modifying the sampling method as necessary.

Freshwater Ecosystems Summary
• Ohio is routinely using IBI and biosurveys, as well as physico-chemical sampling, to manage their water resources. These methods are also being used to evaluate the effectiveness of abatement activities.
• The biocriteria approach allows for the effective identification of damaged aquatic resources, even in cases where physico-chemical sampling fails to detect the abuse.

4.2.2 Indices of Biotic Integrity[10]

James R. Karr *Director, Institute for Environmental Studies, University of Washington*

The primary goal of the U.S. Water Quality Act (1972) is to "restore and maintain physical, chemical, and biological integrity of the nation's waters." Many monitoring agencies are now moving from being primarily concerned with the chemical and physical aspects of water, to using biological indicators as part of an integrated ecological framework that includes humans.

This change in perspective has not come a moment to soon. There are many signs of ill health in aquatic biota across the U.S.:

- many taxa are classed as rare to extinct: 34% of fish species; 75% of unionid mussels; 65% of crayfish;
- 40-70% of fish species are exhibiting major population declines;
- commercial harvests are down by over 80% in U.S. rivers;
- fish consumption advisories occur in about 40 states each year; and
- 60-80% of riparian corridors have been destroyed.

Aquatic biotic integrity can be thought of as the net result of water quality, habitat structure, energy sources, flow regime, and biotic interactions. Different processes drive biotic integrity at different scales (Table 6). Two very useful indices have been derived at the scale of the assemblage: the fish Index of Biotic Integrity (IBI) and the benthic Index of Biotic Integrity (B-IBI). It has generally been found that measurements at the assemblage level are less variable and more rapidly obtained than those determined from measurements of ecosystem and population processes (Hughes et al. 1990).

[10] This section was summarized by David Marmorek.

Table 6 The effect of scale on biological processes affecting biotic integrity.

Scale	Example of Important Process(es)
genetic	mutation
individual	growth
population	demography
assemblage	interspecific interactions, energy flow, nutrient cycling
landscape	water cycle, population sources and sinks

The Index of Biotic Integrity (IBI) measures the health and complexity of a fish assemblage relative to those assemblages at a set of minimally impacted reference sites of similar size from the same ecological region (Karr 1981, Fausch et al. 1984, Karr et al. 1986). These reference sites provide 'biocriteria' by which to evaluate other sites, which are scored on a scale ranging from 12 (very poor) to 60 (excellent). The overall score is made up of 12 metrics, each of which can range from 1 to 5 (1 = deviate greatly from, 3 = deviate slightly from, 5 = similar to, reference sites). These include indicators of taxonomic richness, habitat and trophic specific guilds of species, sensitive (canary) species, generally tolerant species, individual condition, and abundance (Table 7; Hughes et al. 1990). The IBI metrics have differing sensitivities to stressors, but the overall suite attempts to capture responses to a wide range of stressors. These include eutrophication, acidification, contaminants, physical habitat degradation, flow modification, introduced species, thermal pollution and overharvesting.

Although originally developed for streams in the U.S. Midwest, the IBI has been applied to streams and rivers throughout the Midwest and in Oregon, California, Colorado, Appalachia, New England (Miller et al. 1988), as well as southern Ontario (Steedman 1988) and France (Oberdorff and Hughes 1992). These applications have shown that the IBI works well and has low measurement error. The advantages of the IBI are listed in the summary table at the end of this section. Miller et al. (1988) stress however, that the component metrics of the IBI must be tailored somewhat to match regional particularities in fish distribution and assemblage structure.

Table 7 Examples of the components of fish and benthic indices of biotic integrity. The metrics included in the index may change slightly from region to region.

IBI (fish index)	B-IBI (benthic index)
total # species	total # taxa
# darter species	# intolerant snail and mussel species
# sunfish species	# mayfly taxa
# sucker species	# caddisfly taxa
# intolerant species	# stonefly taxa
% green sunfish	% *Corbicula* (a genus of freshwater bivalves)
% omnivores	% oligochaetes
% insectivorous cyprinids	% omnivores and scavengers
% top carnivores	% collectors-filterers
number of individuals	% grazers-scrapers
% hybrid individuals	% strict predators (excluding chironomids and flatworms)
% diseased individuals	total abundance

Indices of Biotic Integrity Summary

Process and Approach

- Index of biotic integrity (IBI) measures the health and complexity of a fish/benthic assemblage relative to those assemblages at a set of reference (minimally impacted) sites of similar size from the same ecological region.
- Overall score made up of 12 metrics, including indicators of taxonomic richness, habitat and trophic specific guilds of species, sensitive (canary) species, generally tolerant species, individual condition, and abundance.
- Metrics of IBI must be tailored somewhat to match regional particularities in fish distribution and assemblage structure.
- This approach is flexible, sensitive, takes into account cumulative impacts, overcomes the weakness of a single parameter approach, and allows for the direct evaluation of the resource condition.

4.2.3 The NAWQA Program[11]

Mark Munn Aquatic Ecologist, U.S. Geological Survey

Beginning in 1991, the U.S. Geological Survey (USGS) started a new initiative known as the National Water-Quality Assessment Program (NAWQA). The long-term goals are to describe the status and trends in the quality of a large, representative part of the Nation's surface- and ground-water resources, and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources.

The NAWQA program consists of 60 large study basins, nationwide, of which the Mid-Columbia River Basin in Washington and Idaho is one unit. To meet its goals, the program will use an integrated approach, seeking "converging lines of evidence" pertaining to water quality at local, regional, and national scales. The surface water component will locate sampling sites based on a land-use stratification process that considers natural features such as geology and soils, and land-use conditions (e.g. urban, agricultural). Two types of sites are recognized in this program:

1. indicator sites (located within a "single" land use type); and

2. integrator sites (covering multiple land uses).

For the first three to four years of the program, an intensive data collection will be undertaken at each of the sites, after which trend monitoring will occur.

Each of the 60 study basins will encompass about 100 stations. Sites are chosen to reflect ambient surface water conditions as opposed to point-source influences. A site consists of a river segment containing sample reaches (Figure 4). Sample reaches include two riffle-run-pool sequences (100-300 m). At each site there may be a variety of studies such as microbiological conditions, tissue analyses for fish and invertebrates, ecological surveys, toxicity studies, and investigations of biogeochemical processes.

The ecological surveys focus on three communities: fish, macroinvertebrates, and algae. For each community the investigation includes both quantitative and qualitative samples. Invertebrates will be sampled at all sites, and fish will be sampled at only about one-third of the sites. Special effort is also devoted to physical habitat studies. Trend studies will be limited to three to four sites, and will employ quantitative methods, with increased replication. Quantitative samples will be obtained, for example, by compositing multiple macroinvertebrate samples taken from riffle and depositional environments.

The products from the ecological studies will include:

1. maps showing the occurrence and distribution of species;

2. site comparisons (multivariate analyses, paired sites within strata, longitudinal patterns);

[11] This section was summarized by David Bernard.

3. information on sources, transport, fate, and effects of contaminants;

4. data concerning influences of physical and chemical parameters on species distributions; and

5. a database of species tolerances.

These products should allow the USGS to: present a nationally consistent picture of surface water quality; detect and describe long term water-quality trends (discrete three-year periods); and identify major factors affecting water quality.

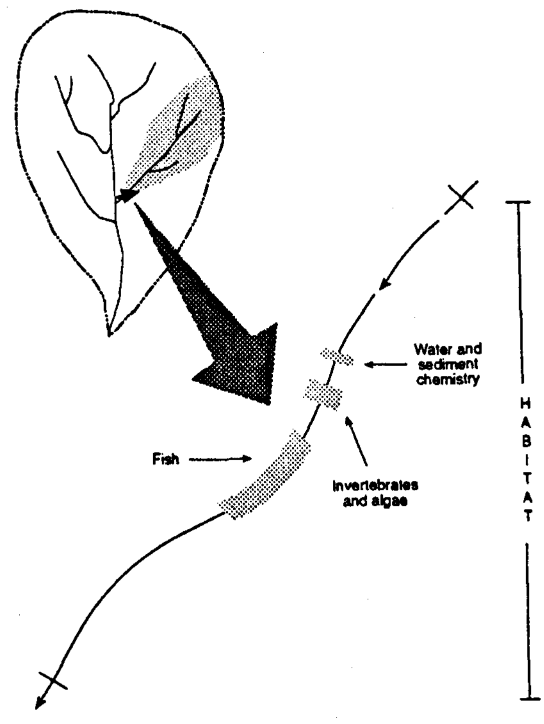

Figure 4 NAWQA Program sampling strategy

The 60 basins nationwide will be investigated in three sets of 20. Sampling in the Puget Sound region is scheduled to begin in 1994.

The NAWQA Program Summary
• The NAWQA program will sample both indicator and integrator sites for physical and chemical conditions, microbiological conditions, tissue analyses and ecological surveys that use biological end points.
• The products of this study will contribute to a national picture of water quality and will identify major factors affecting water quality.

4.3 The EMAP Approach to Near Coastal Ecosystems[12]

Steve Weisberg *Scientist, Versar*

The Environmental Monitoring and Assessment Program (EMAP) is a national monitoring program to assess the condition of the United States' ecological resources. The program is led by the U.S. Environmental Protection Agency, with extensive participation and cooperation from federal and state agencies. EMAP aims to fill the niche of integrated, regional and national scale assessments, and to answer the following questions:

- What is the current status, extent, and geographic distribution of ecological resources (i.e. forests, near coastal waters, inland waters, drylands and range lands, wetlands, and agro-ecosystems)?

- What proportions of these resources are degrading or improving, where, and at what rate?

- What are the likely causes of adverse effects?

- Are adversely affected ecosystems responding as expected to control and mitigation programs?

These questions are being addressed using multiple indicators for each resource type, and are implemented on a consistent, unbiased sampling frame. The Near Coastal component of EMAP has begun by addressing these questions for the estuaries of the Virginian Province, an area extending from Rhode Island in the north to Virginia in the south. A Demonstration Project was carried out in 1990 to generate preliminary status estimates and assess feasibility.

Careful selection of indicators and strong sampling design are the two pillars of EMAP. Figure 5 provides an overview of the indicator strategy, which was developed through the following systematic process:

1) define issues and endpoints of concern;
2) develop a conceptual model linking stressors, inputs, indicators, and endpoints;
3) identify candidate indicators using the model;
4) screen and classify indicators according to evaluation criteria;
5) conduct indicator testing and evaluation to identify a core program; and
6) re-evaluate all of the above periodically.

With respect to the first critical step, two major sets of issues were identified: the inputs of pathogens, toxic contaminants, nutrients, and solids and the removal of natural resources (fish, shellfish, and wetlands). Two overall assessment endpoints were selected: biotic integrity (kinds and abundance of biota, ecological processes) and human usage (aesthetics, human exposure). The 1990 Demonstration Project included indicator testing and evaluation sites to determine the reliability, sensitivity, specificity, and repeatability of indicator responses for discriminating between polluted and unpolluted conditions. This was the fifth step in the above-described process

[12] This section was summarized by David Marmorek.

process of identifying indicators. Indices of benthic community structure proved to be the most efficient at discriminating between polluted and unpolluted conditions.

The sampling design is as critical to the success of the program as is indicator selection and testing. The core of the design involves probability samples from three classes of systems: large estuaries, large tidal rivers and small estuaries. The sampling design was tailored to allow statements of resource condition to be made for each of these types of systems. Sampling sites in large estuaries (n=54) were selected using an enhancement of the hexagonal grid being used throughout EMAP (Overton 1989). Large tidal rivers (n=25) were sampled using a "spine and rib" approach (Weisberg et al. 1992). The starting point of the spine was at the mouth of the river, and the first transect ("rib") was located at a randomly selected river-kilometre between 0 and 25. Additional upstream transects were placed every 25 km from the first, with sampling sites selected at random along the rib of each transect. Finally, a subset of small estuaries (n=32) were randomly selected from list of all such systems in the Virginian Province (Weisberg et al. 1992). Other near coastal regions, involving seven biogeographical provinces, will be sampled using the same methods, allowing comparisons across regions.

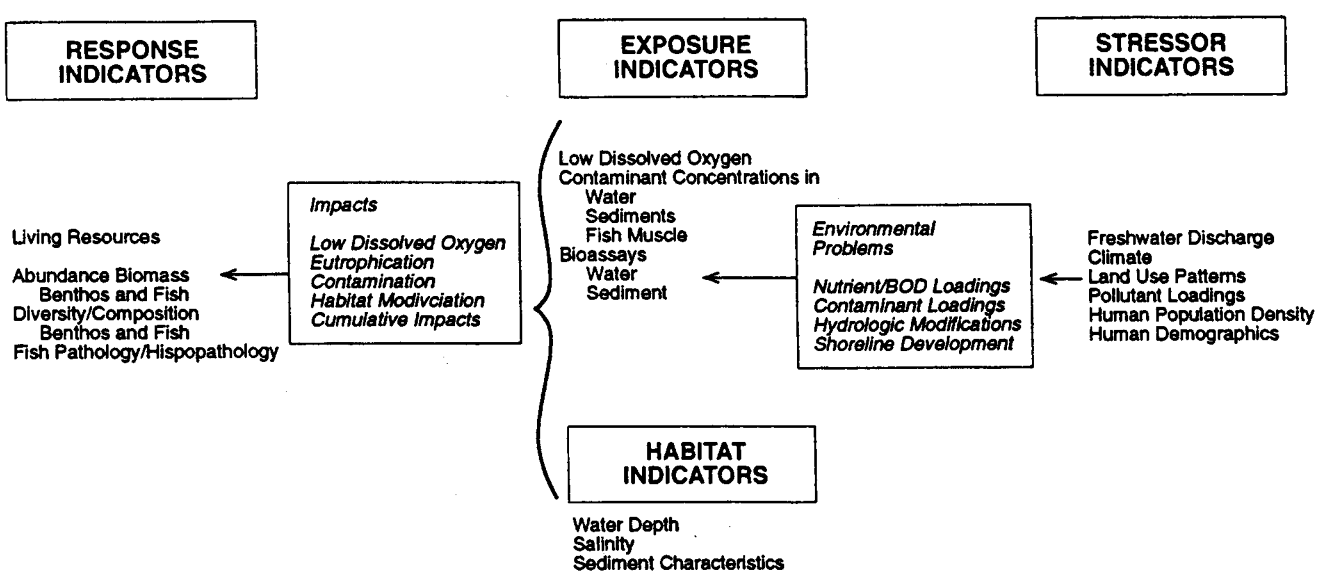

Figure 5 Overview of the EMAP Near Coastal indicator strategy.

Examples of the results of the near coastal program are shown in Figure 6. The graphs require judgements concerning the boundary between degraded and non-degraded resources. Should these judgements change with more research, the design allows a recalculation of status estimates, based on the cumulative frequency distributions of each indicator and aggregate index.

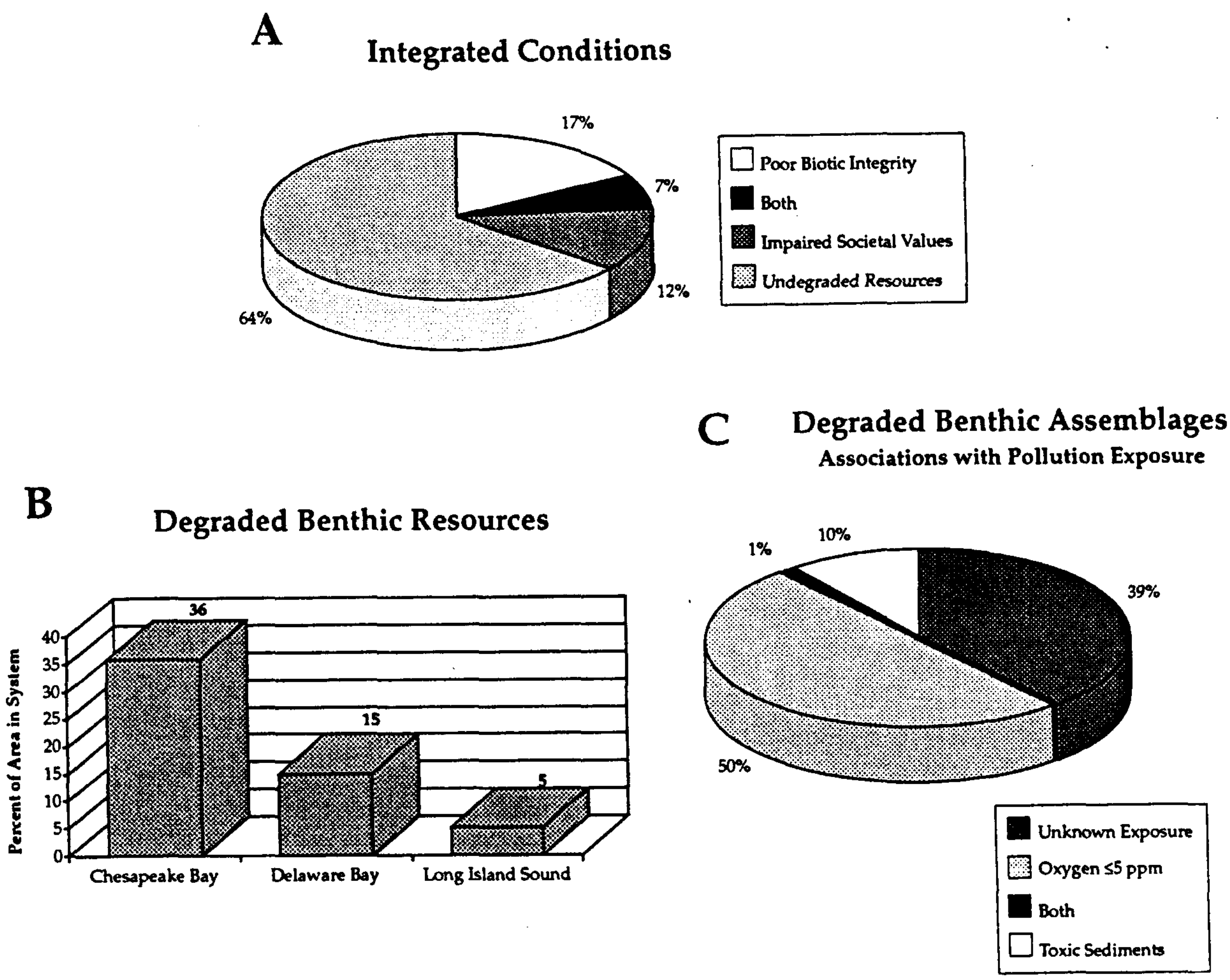

Figure 6 Examples of output from the EMAP Near Coastal program. A. Summary of environmental conditions in all of the estuaries of the Virginian Province. B. The proportion of degraded benthic resources across the three largest estuaries. C. Associations of degraded benthic assemblages with the dissolved oxygen and sediment toxicity pollutant exposure indicators.

EMAP Near Coastal Program Summary
• A demonstration project determined the sensitivity of indicator responses for distinguishing between polluted and unpolluted conditions. • The rigorous sampling design uses a probability sample to ensure that sampling sites are truly representative. • Indicator testing and evaluation is carried out across a strong stress gradient. • This approach gives unbiased, regional scale estimates of the resource condition over time, ensures that all types of resource areas are subject to sampling, and is driven by assessment endpoints that have been confirmed by managers, scientists, and the public.

4.4 Landscape-level Ecosystem Objectives: Fisheries-Forestry Interactions[13]

Steve Chatwin *Manager, Fish/Forestry Watershed Assessment, Research Branch, Ministry of Forests*

Small coastal watersheds are examples of complex, dynamic systems that are vertically integrated. Activities in the upper reaches of these watersheds can have pronounced effects on their lower parts. There have been considerable conflicts between fisheries and forest resource managers resulting from the detrimental impacts of upland forest harvesting activities on downstream fish habitat. In B.C., a growing body of scientific knowledge about the dynamics of these watersheds can be directly applied to the definition of ecosystem management objectives.

Research at Carnation Creek and in other locations, such as the Queen Charlotte Islands, has repeatedly shown that a good understanding of the dynamics and changes in these systems is required, even for the selection of the indicators that are monitored for ongoing changes. Some of the indicators that were initially selected to monitor changes turned out to be less useful than initially thought. For example, flow and bedload sediment do not show significant changes after landslides in coastal watersheds.

Channel morphology should be used as a biological/physical integrator of the dynamics of coarse woody debris, slope dynamics, and fish habitat. The important changes going on in the system are due to sediment storage patterns, not sediment throughput. Historically, large storms have triggered landslides and mass wasting, resulting in the periodic input of trees and coarse woody debris into channels and all reaches of the watersheds. Large stems result in log jams that alter the stream and sediment dynamics and create fish habitat. Maintenance of suitable habitat thus depends on the periodic input of large size logs that form barriers and affect flow rates.

Forest management and harvesting directly affect the rate and type of log input into reaches of the watersheds. Removing large-diameter and old-growth logs from stream banks reduces the supply of future material for log jams. In some cases, the creation and maintenance

[13] This section was summarized by Werner Kurz.

of growing sites that support large diameter Sitka spruce trees is dependent upon such trees falling and in turn blocking water flow and encouraging sedimentation. Landscape-level management thus needs to consider how the removal of logs will affect future channel morphology and the maintenance of growth sites for Sitka spruce and fish habitat. The size of buffer strips and the required log diameters depend on the size of the channels, slope gradients, and peak flow events. Decisions about road location and road building techniques also need to reflect objectives about sediment input and reduction of landslide activities.

For many coastal areas in the province, air photo records taken fifty years ago permit retrospective analyses of landslide activities and changes in channel morphology. Recent low-level photographs taken from helicopters provide additional sources of information about changes in channel morphology.

These forestry-fishery interaction studies emphasize the following needs: to select indicators at the correct spatial and temporal scales; to be cognisant of the dynamics of the slow elements of the system, such as large decaying logs that alter channel morphology and fish habitat; to properly understand the impacts of management decisions on the dynamics of the system; and to better understand the role of "ecological rotations" and the criteria by which to decide on the size and characteristics of buffer strips in the various parts of coastal watersheds.

Landscape-level Ecosystem Objectives: Fisheries-Forestry Interactions Summary

- Forestry-fisheries interactions are an example of complex, vertically integrated systems, the components of which operate on very different temporal and spatial scales.
- Changes in channel morphology are a good integrator of the dynamics of several system components.
- Air photos taken 50 years ago, as well as recent photos, provide us with information about landslide activities and changes in channel morphology.
- We need to further our understanding of system dynamics.

5.0 Synthesis of Working Group Discussions

This chapter provides a synthesis of the discussions which took place within the seven working groups. The groups included two on aquatic ecosystems, one on near coastal ecosystems, two on terrestrial ecosystems, and two landscape groups which considered interactions among the other ecosystem groups.

Each of the groups attempted to proceed through the following set of structured exercises. Because the workshop was exploring new territory, the purpose of these exercises was not to produce specific products or ends, but to experiment with the *process* of setting and implementing ecosystem goals and objectives. Working groups chose to focus on those steps or topics they found most relevant to their needs.

5.1 Structure of the Discussions

Prior to the workshop, a series of steps were developed to guide the working groups in formulating ecosystem goals and objectives for parts of the Fraser River Basin:

1. define and provide examples of the ecosystem type: some in relatively pristine condition in need of *protection*, and some disturbed ecosystems in need of *restoration*;

2. visualize a desired future state for each of these ecosystems that includes the role of people;

3. describe this future state in words and/or pictures (a cooperative effort created by combining independently conceived and generated elements), to serve as ecosystem goals (see Figure 7);

4. list current and potential stresses or threats to that desired state;

5. review lists of ecosystem objectives and emergent properties generated elsewhere (e.g. Harris et al. 1987) to select those most appropriate to the group's ecosystem goals, and evaluate how the Fraser River basin is different;

6. attempt to generate the "missing" ecosystem objectives required to support stated ecosystem goals, that are not available from other studies;

7. determine what information is required from each of the other ecosystem groups (a Looking Outward exercise); and

8. critically evaluate the group's proposed goals and objectives, and the process used to generate them, considering how the public and institutions could work together to apply this process;

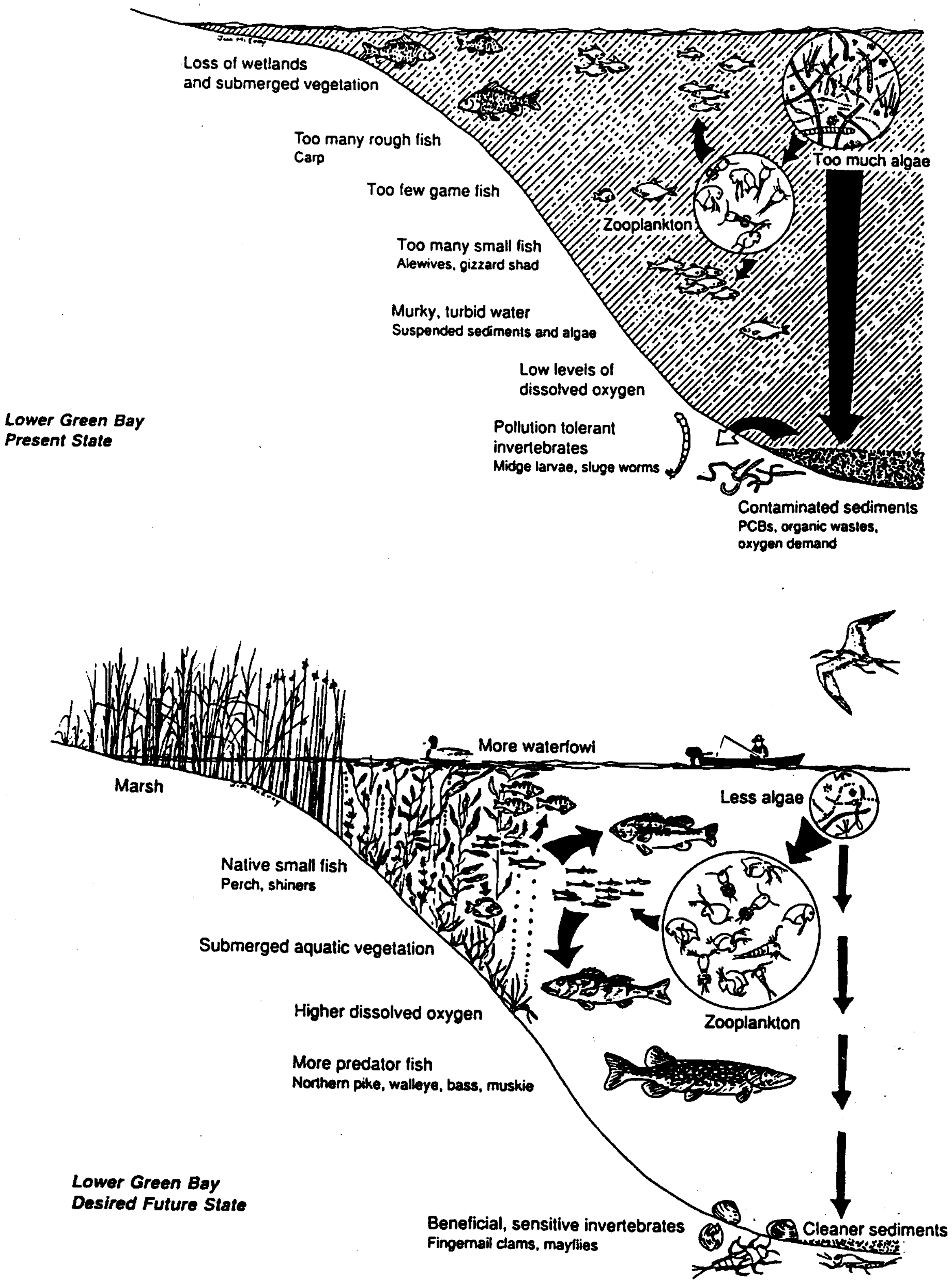

Figure 7 Illustration of a conceptual model used in development of ecosystem goals and objectives in Green Bay.

9. brainstorm possible uses of the ecosystem approach to deal with pressing issues in each ecosystem (e.g. setting effluent permits, deciding on timber cutting plans, evaluating coastal development applications);

10. imagine processes to involve the public;

11. determine methods of interagency and intra-agency integration; and

12. review methods of ecosystem management (e.g. monitoring, experimental management, data management, modelling, research, development of indicators).

The working groups touched on most of these steps in their discussions, but there was neither sufficient time nor interest to systematically pursue each exercise. Each working group had the freedom to pursue the steps and themes of greatest interest to the participants, while following the general intent of the above exercises. While many of the ideas generated by the groups are incomplete, they provide a starting point for grappling with how to apply the ecosystem approach to different ecosystems at various spatial scales within B.C. The discussion summarized below does not represent a consensus among the groups; rather, it represents the primary outputs of all of the combined groups. The topics used as foci for the synthesis that follows were common issues raised in the workgroup discussions.

5.2 Definitions of Ecosystem Goals and Objectives

Several participants at the workshop felt that it was important to clearly define ecosystem 'goals' and 'objectives', so that efforts to generate them could be well focused. For example, as summarized in earlier sections of this report, a variety of different approaches have been used to define ecosystem goals and objectives. Compare, for example, the fairly qualitative aspect of the Lake Ontario ecosystem objectives (Table 2) with the detailed quantitative targets developed for the Green Bay ecosystem in Lake Michigan (Table 4).

Table 8 is an attempt to provide operational definitions for a set of terms that form a basis for the ecosystem approach. This table was generated by the near coastal subgroup and was presented to the workshop participants at the final plenary session. There was general agreement at the workshop that objectives should include specific indicators and targets. It was also recognized, however, that quantitative targets are difficult to set - experimental research, management, monitoring, and lots of professional judgement is required to determine them.

Table 8 Operational definitions of ecosystem goals, objectives, strategies and actions.

Term	Operational Definition	Examples
Goals	What do you want? What's most important?	Maintain or improve water quality and aesthetics to encourage human contact (e.g. swimming).
Objectives	System properties necessary to achieve goals. (Each objective may serve several goals; each goal may require several objectives.)	Meet recreational water guidelines. Prevent excessive, unaesthetic algal growth due to anthropogenic nutrient enrichment. Prevent accumulation of persistent marine or riverine debris.
Indicators	One or more measurable variables in support of each objective.	Faecal coliform levels.
Targets	A specific target for each indicator or index (set of indicators).	Geometric mean < 200 per ml.
Strategies	What can we control to attain indicator targets?	Sewage treatment plants, storm drains, combined sewer overflows, agriculture, boats.
Actions	Who will do what to implement the strategy?	FREMP discussions -> actions by GVRD, DOE, MELP, City of Vancouver, farms, Port of Vancouver, Harbour Commission.

Subgroups were asked to visualize and describe a desired future state for each of their ecosystems (steps 2 and 3 in the procedure outlined in Section 5.1). The groups came up with a set of ecosystem goals, which are outlined in Table 9. Although each subgroup was considering separate geographic areas and sometimes very different types of ecosystems, many of the goals that emerged were similar. Goals identified by most of the subgroups included consideration of *sustainability*; *aesthetics*; natural, human, and monetary *resources*; *education*; biological, economic, and land use *diversity*; and the fact that economic and social issues must accompany any consideration of the natural environment. Many participants commented that the workshop was an artificial setting for determining ecosystem goals, since real stakeholders were not involved. They nevertheless tried to consider stakeholder perspectives in their suggested goals.

Table 9 Specific ecosystem goals suggested by working groups.

Biology/conservation goals:	• maintain an ecosystem which supports diverse, healthy, reproducing and self-sustaining biological communities in dynamic equilibrium; • maintain resilient and sustainable ecosystem structure, function and processes; • maintain biological diversity (including avoiding species extinctions); • protect indigenous biota, and ensure there are no observable effects on wildlife and human health; • maintain/restore/improve ecosystem health; • environmental stewardship.
Resource goals:	• ensure the human population uses resources in a sustainable manner; • maintain and enhance harvestable resources free of contamination, disease or aesthetic abnormalities that reduce their desirability; • protect and enhance natural resources, with emphasis on aquatic systems; • ensure water resource conditions that protect human health and provide sustainable harvest of aquatic and related resources; • ensure individuals and society consume resources at a rate that does not compromise future generations, with no net increase in waste production (decrease if possible); • ensure adequate and sustained levels of resources (funding and human) to realize goals and objectives.
Aesthetics goals:	• maintain or improve water quality aesthetics to permit and encourage human contact (e.g. swimming)
Socio-economic goals:	• maintain human health; • maintain economic and social well-being; • maintain stable communities with a sustainable economic base, and where change is necessary manage a gentle transition to minimize impacts on society; • foster ecological literacy in individuals and society through public education; • have an ecologically informed public living in harmony with their environment, which includes educating communities as to how their lifestyle affects the natural environment.
Planning goals:	• limit population growth; • reduce anthropogenic stresses both locally and externally; • establish a land/water use planning framework to guide development, instead of post-development mitigation; • recognize conflicting land/resource uses and find process through which society can choose and make trade-offs; • establish sound scientific knowledge/databases to support development of ecological objectives, ecosystem management, and measurement techniques; • secure coordination/cooperation with the public, government, university, and others; • maintain a diverse landscape that provides attractive viewsheds, recreational opportunities, housing and industrial use with minimal impact on adjacent systems.

5.3 Ecosystem Stressors

Having identified various ecosystem goals, workgroup participants were asked to identify the current and potential stresses or threats to the desired future state of their particular ecosystem. Table 10 lists all of the stresses that the subgroups identified. Some stresses were identified by only one or two subgroups, but population growth, urban development, sewage, industrial effluent, and changing water flows were identified by almost all of the subgroups as being of concern.

Table 10 Ecosystem stressors. These stressors are described according to the concerns that were raised during the subgroup discussions.

Stressor	Description/Elaboration
population growth	This may be the primary stressor for a number of stressors listed below, and was considered the root of much of the pressure on natural ecosystems.
forestry	This includes the range of forest practices, from site preparation through timber harvest and post-harvest activities. It also includes fire suppression, which in turn can lead to increased susceptibility to insect infestations. Effects of forestry activities on habitat and wildlife movement was of concern.
agriculture	This includes irrigation, water consumption, and the use of herbicides and pesticides.
grazing	There was concern about pressures from overgrazing as well as the grazing impacts on riparian habitat.
mining	Specific concern was expressed regarding acid mine drainage.
hunting/fishing	This includes overharvesting, and fish/animal harvest outside the boundaries of the chosen area (e.g. if the area is a watershed with a salmon spawning river, then the offshore salmon fisheries will affect fish returning to this watershed).
gravel extraction	The use of stream beds for gravel borrow pits may destroy fish spawning grounds.
utility corridors	This includes roads, railways, hydroelectric power lines. Roadways also create access for an expanding population, exacerbating problems such as land use conflicts and habitat loss.
urban development	Urban sprawl or expansion leads to habitat loss. It was acknowledged that this doesn't have to be an urban centre per se, that "municipal" development can have the same effect. In addition to the space problem, this also includes pressures resulting from increasing urbanization, such as waste generation and disposal.
sewage	Concern was expressed about sewage, in its various treated forms. Concerns included increased nutrients in waterbodies, and the health risk from faecal coliforms.
industrial effluent	Pulp mills were specified, with contaminated effluents leading to sediment contamination, bioconcentration, and fish closures.
climate changes	Concerns ranged from local temperature changes to global warming and El Nino.
ozone depletion / UVB	Although this is a global problem, it causes local concern.
air quality	Pulp mill emissions were specified, but this includes a range of emission concerns from point and non-point sources.
changing water flows	This includes flow regulation from dams, and effects of increased temperatures on aquatic biota.
soil salinization	This is generally the result of poor irrigation practices.
non-point source pollution	This includes air particulates such as smoke from wood-burning stoves and beehive burners, pesticides from golf courses and home gardens and lawns, and storm sewer outfall pipes.
accidental spills	Specific concern was expressed about oil spills, and spills along transportation corridors.
erosion	This includes wind erosion of agricultural soil.
exotic species	A number of exotic species are threatening ecosystems in B.C., including Eurasian water milfoil, purple loosestrife, and knapweed.
natural processes	Anthropogenic stressors are not the only factors that may drastically alter ecosystems. For example, severe outbreaks of certain pests may dramatically alter the age and species composition of forested areas.
lack of economic opportunity	This refers to the loss of jobs from decreasing resource extraction (e.g. the falldown effect from a decreasing supply of timber due to a gradual conversion from old growth to second growth forests, and changing forest values).
lack of cultural opportunities	This may be a problem in some areas, although concern over this will vary among community members.
social/political reality	This includes a number of factors such as fragmented authority and responsibilities, political ambitions, loss of public trust and support, lack of public commitment, lack of ecological literacy, and rising public expectations.
conflicting land use pressures	As the population increases, so does the demand for land use. Expected conflicts include forestry versus roads, recreational use of water reservoirs versus fish populations versus agricultural use, forestry versus rangeland, and land claims issues.
foreign events	Events in distant parts of the globe may affect ecosystems in B.C. For example, tropical deforestation may affect habitat for, and ultimately cause a decline in the numbers of migrating species.

There is some overlap between these stressors. For example *non-point source pollution* stressors such as wood burning stoves could also be categorized under *air quality*. Some stressors listed can be considered as subsets of others, for example pesticide use is a *non-point source pollution* stress that can also be categorized under *agriculture*. They also may describe different "orders" of stressors. For example, *conflicting land use pressures* could be described as a secondary stress resulting from the primary stress of *population growth*.

5.4 A Procedure for Setting Goals and Objectives

Subgroups discussed the practical details and process of setting ecosystem goals and objectives in British Columbia. Together the groups generated a set of key questions that should be explored and answered as part of an ecosystem approach to natural resource management:

- what do you have now?
- what do you want in the future?
- what can you get?
- how do we get to the new system state?
- are management activities working?

In attempting to synthesize working group discussions, a 7-step procedure emerged as a useful way to answer these questions. This procedure is illustrated in Figure 8 and described below.

In many ways, the procedure is analogous to the structured exercises undertaken by the groups as they worked on the process of setting and implementing ecosystem goals and objectives (described in Section 5.1). However, the procedure provides some practical details for actually doing what the structured exercises outlined in only general terms. Figure 8 and the following sections describing each step are not by any means definitive; rather, they are meant to stimulate further thinking on the process of setting goals and objectives.

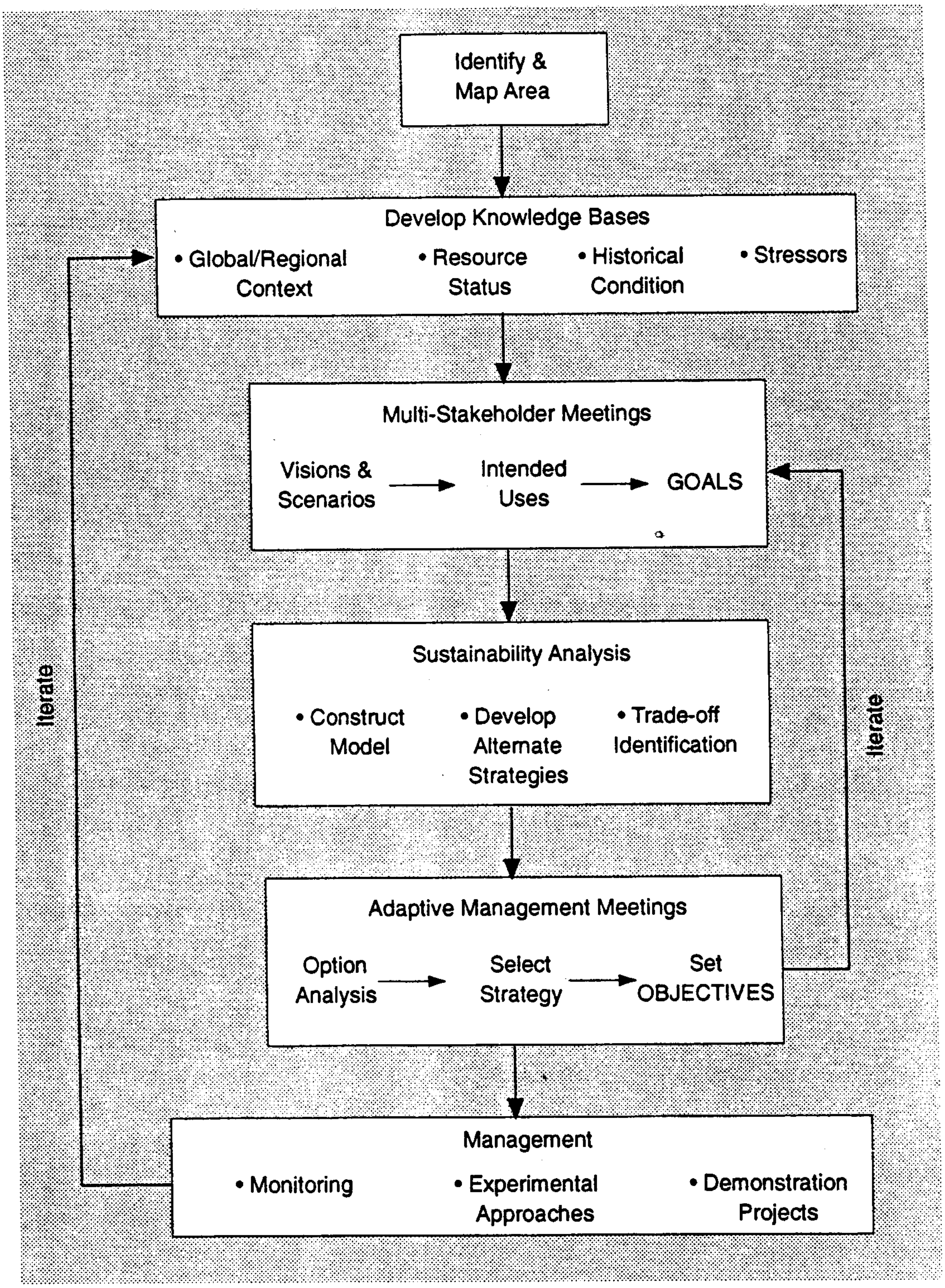

Figure 8 Proposed process for setting and revising ecosystem goals and objectives

5.4.1 Identify and Map Area

The first step is to define the ecosystem of interest and to develop suitable maps describing the area and its important features.

5.4.2 Develop Knowledge Bases

The next step is to develop knowledge bases pertaining to key topics such as: 1) stressors affecting the ecosystem; 2) status of resources and services supplied by the ecosystem; 3) historical condition of the ecosystem; and 4) the global/regional context. It is important that data be accessible to all of the stakeholders. The main purpose of this knowledge base is to provide the information and data needed to answer the question "what do you have now?".

5.4.3 Multi-stakeholder Meetings

The workgroups were asked to consider the process by which both the public and institutions could generate ecosystem objectives. It was felt that the core of any process designed to establish ecosystem objectives must be the identification of ecosystem goals. Participants at the workshop indicated that multi-stakeholder meetings are an appropriate forum for identifying these goals. It was felt that stakeholders should complete a set of exercises, similar to those outlined in Section 5.1, to assist in determining the desired future state of an ecosystem. The net result of the multi-stakeholder meetings should be an authoritative answer to the question "what do you want?".

5.4.4 Sustainability Analyses

In some cases, the stakeholders' desired ecosystem state may not be attainable or sustainable. For this reason it is important that the overall process contain a step intended to identify trade-offs and to develop alternative strategies for achieving intended goals. This might involve the use of a wide variety of approaches, ranging from conceptual and/or simulation modelling to expert judgement. The final output from this process would answer the question "what can you get", and would provide information on pathways most likely to move the system toward the goal.

5.4.5 Adaptive Management Meetings

Once the sustainability analyses are complete, it is time to call another meeting(s) with the stakeholders. The purpose of these meetings will be to present and discuss the quantitative analyses and available options. In time, the stakeholders would be encouraged to select a strategy and to set objectives, using quantitative indicators and targets whenever possible. In some cases, stakeholders may wish, or need, to revisit earlier discussions pertaining to visions, intended uses, and goals. One objective of these meetings is to reach consensus on how we can get to the new system state.

5.4.6 Evaluate Management

Since managing by ecosystem objectives is a relatively new approach, it is important to continually evaluate the degree to which goals are being achieved. In many cases it will be necessary to adopt an experimental management approach. Monitoring data and information are essential to evaluate the utility and success of those "experiments". In some cases, before the management approach is put into widespread use, it will be helpful to have results from demonstration projects. In the spirit of exploring new territory and approaches, it will be valuable to periodically both ask and then answer the question "how are we doing, and are the management activities working?".

5.4.7 Iterate

Depending on the outcome of the management review, and on changing environments or social and economic circumstances, it will be essential to regularly repeat and go through the process again, to ensure that the goals and objectives are current, and that the management practices are achieving the desired outcome.

5.5 Essentials for Public Participation

Most workshop participants have had personal experience with a public participation process. This is not surprising, considering that, as one participant stated, there have been about 300 such processes in British Columbia in the past few years. The workshop generated lots of good ideas concerning the critical ingredients for a successful public participation process.

Workshop participants felt that public participation is central to the success of an ecosystem approach - stakeholders must not only be involved, but they should lead the process. Participants in an effective process should include: citizens, natives, industry, special interest groups, municipal government, local resource management committees, provincial resource agencies and federal agencies.

The workshop groups felt that for a public participation program to be effective, four main points must be addressed:

- participants must be educated in ecosystem ideas;
- participation must lead to results;
- confusion and burnout of participants must be avoided; and,
- institutions must change.

The general public must be educated on this new way of thinking. Participants of public processes must be given up-to-date information, including syntheses of past and current conditions, and an explanation of the indicators used to arrive at this knowledge (i.e. the first two steps in Figure 8). Government agencies must be encouraged to adopt an ecosystem approach in existing processes. Schools, colleges, and universities should educate the new generation and their parents. Information and funding could be provided to put the new approaches into practice in demonstration projects. The role of scientists in this activity could be to: help stakeholders to set ecological goals; provide objectives for natural systems that take into account their long term health; provide tools and information; and provide decision makers with professional judgement on prudent actions.

For participation to lead to results, a number of features must be in place. Participants felt that the public must clearly understand the constraints under which decisions are made. Recommendations to cabinet must be seen to be taken seriously, particularly if they are not accepted. There must be a political commitment to action, and long-term support must be assured. There should be a senior legislative mandate for change. As much as possible, local changes must be left up to local discretion. Finally, process participants need to be given feedback on the effectiveness of their work. This feedback could consist of information from monitoring programs and timely syntheses of results. An ongoing mechanism for informing the public should be established.

Confusion and burnout of participants in public processes must be avoided. Often the same people are being asked to contribute their time voluntarily to several different processes. Rather than inventing new processes, existing processes (e.g. FREMP, CORE, LRMP, Protected Areas Strategy, the Round Table) should be enhanced. In some cases the mandates of these existing processes should be altered to reflect an ecosystem approach.

Finally, institutions must change. We need to identify and address the barriers to change and we need to provide incentives and rewards for all levels of government to adopt new ways of thinking. We need to encourage heroes.

We should take this opportunity for team building across agencies. The ecosystem approach can provide experience and technical knowledge to public and institutional processes. It can contribute to an understanding that planning boundaries must be ecosystem boundaries as recommended by Stan Rowe in his presentation, and can help to separate large scale issues from local issues. Possible formats could include an ecosystem advisory board, with a mandate to incorporate ecosystem objectives that explicitly recognize ecosystems to consist not only of the environment, but also society and economy. An ecosystem monitoring program, integrated with existing databases, could be effectively delivered and easily accepted.

Table 11 is a synthesis of several lists generated in subgroups. Workshop participants were asked to think for a minute about their experience with public participation, and to list the one or two most important lessons they had learned. Each participant contributed an item to a group list, avoiding duplication. While the process of generating a group list led to valuable interaction among participants, it should be kept in mind that agreement was not sought on individual items.

Table 11 Some essentials for public participation processes.

Before	• the process should have a clear mandate; prepare; • commit the time required to reach consensus (months or years), if stakeholder consensus is sought; • have enough and the right information available for the public; • don't let the press get involved too early [some disagreement here]; • consider working together with other agencies; • involve "gurus" or mentors; • establish whether stakeholders are willing to compromise; • ask stakeholders to be open about their "mission".
Beginning	• involve the public from day 1; • ask for concerns; • advertise early; • invite everyone; anyone who wants to participate should be allowed to; • establish a common vocabulary; • establish open communication ("put everything on the table"); • establish ground rules (i.e.: rules of order, conflict resolution mechanisms) that all can live with; • be flexible in changing the process; • establish a level playing field: recognize that some presenters are paid for their time (by their workplace) and consider financial assistance for others; • consider providing courses for the public (some of the public may need a great deal of background in order to participate effectively).
During	• ask the right questions; • show that you are willing to listen ("consult"); • provide skilled and neutral facilitators (they may need to act as "translators" between stakeholders); • involve the public in an analysis of trade-offs (scientific and technical resource people may be needed); • operate in such a way that participants feel "ownership" of the outcome; • have an "open mailing list" and mail summaries to those who can't attend; • draw out the values of stakeholders; • hope no other public process comes to town!
Ending	• have a clear end point; • show results.

6.0 Future Directions Revisited

6.1 Challenges and Opportunities[14]

Throughout the workshop, in both subgroup and plenary discussions, a number of important challenges to the development and implementation of an ecosystem approach in B.C. were identified. While these challenges could be perceived as barriers to adopting the ecosystem approach, they can also be viewed as opportunities for innovation and creative change. Both challenges and opportunities are presented below.

6.1.1 Scale

Throughout the workshop, the scale-dependence of ecosystem goals and objectives emerged as an important challenge in taking an ecosystem approach. Stan Rowe's metaphor of ecosystems as nested Russian dolls is appropriate, except that different sized dolls look and behave differently! It was recognized by the workgroups at the workshop, particularly in the landscape subgroups, that the properties or characteristics of ecosystems vary with their scale. For example, biodiversity will naturally increase as the size of an ecosystem increases simply because a greater variety of habitats are included in the system. At smaller scales, an ecosystem may appear quite transitory, subject to both natural (e.g. fire) and human (e.g. harvesting of renewable resources) disturbances. In the context of a larger regional ecosystem, changes in smaller ecosystem units may be averaged, imparting a semblance of stability to the *whole* system. Indeed, what appears to be a catastrophic disturbance for a small-scale ecosystem may be an essential function in the much larger-scale ecosystem to which it belongs. For example, natural landslides in the Queen Charlottes may wipe out trees, but create vital habitat in streams, as explained by Steve Chatwin.

Time scales were also recognized by participants as an important consideration. From the perspective of one human generation, an ecosystem such as an old-growth forest may appear quite stable. However, over numerous generations these systems may actually look quite dynamic. Considerations of sustainability and ecosystem health will take on different meanings as the ecosystem scale changes.

Although natural and social scientists are beginning to explicitly recognize the importance of scale considerations in studying and understanding ecosystems, policy and management are still grappling with the problems of scale. For example, at what scale should preservation goals be set? On a global level, most participants seemed to agree with the 12% goal for land area preserved in parks and reserves. Participants also seemed comfortable with this goal at a national or even provincial level. However, questions were raised regarding the appropriateness of this goal at regional or local scales. Similarly, what is the most appropriate time scale over which to pursue this goal?

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14 This section was summarized by Trent Berry and David Marmorek.

Such a goal would probably be impossible in some regions of the province (e.g. the Lower Mainland), given current and projected levels of population and development. Indeed, the feasibility and desirability of promoting the tremendous shifts in population and development required to achieve such a goal is questionable, at least within the typical planning horizon of provincial and municipal governments. From a provincial perspective, sustainability might be achievable over a much shorter time frame; however, this implies that unsustainable regions are subsidized by the surplus of sustainable regions.

This scale-dependence of goals or objectives creates additional challenges to an ecosystem approach. For example, there was a great deal of tension between top-down and bottom-up approaches to goal-setting. Many subgroup discussions took a local or regional perspective, focusing on relatively short time scales. This approach grows naturally out of concerns voiced in local stakeholder meetings.

Though the workshop participants did not discuss this possibility, there may be a danger that many goals which are important for preserving larger-scale regional, provincial, national or global ecosystems may fall through the cracks in local or regional goal-setting processes. A hierarchy of goal-setting processes across a number of spatial scales seems to be required. Larger-scale goals might set the context for smaller-scale processes, possibly imposing constraints on local goal-setting processes. The challenge will be reconciling the need to set goals at larger scales with the demand for local control. However, local considerations must also enter into larger-scale goal-setting processes. The Commission on Resources and Environment (CORE) process in B.C. may offer a model for a provincial planning process which reconciles some of the tensions between top-down and bottom-up approaches to goal-setting. Recent initiatives in the Fraser River Basin such as the newly formed Fraser Basin Management Board will also have to address this scaling problem by achieving basin-wide objectives while meeting the demands for local control. The presentation by Tony Dorcey stressed the importance of coordination and negotiation among many different levels of government and types of stakeholders, as a way of resolving conflicts between local and higher levels. Nancy McKay illustrated the importance and effectiveness of cross-level discussions in the implementation of the Puget Sound Water Quality Management Plan.

Considerations of time scales pose similar challenges. Both short-term and long-term goals are necessary, but it is the long-term which must set the context for short-term goals.

6.1.2 Conflicts

From the discussions at the workshop, it appears that the conflicts between local, regional, provincial, national, and global interests, and between top-down or bottom-up approaches to planning and management pose the greatest challenge to implementing a truly ecosystem approach to management. How can we harmonize goals across a range of space and time scales in a manner which minimizes conflict? As stressed by Tony Dorcey, the first step is to recognize conflict as an inherent component of ecosystem approaches to management, particularly given the range of stakeholders. Conflict should not be avoided, but rather explicitly identified, analyzed, and resolved through negotiation and mediation. Conflict, when managed properly, can create opportunities for creativity and innovation. Once again, creative public participation schemes which move participants beyond positions to interests are required to resolve some of these conflicts. The work by the Puget Sound Water Quality Authority is a laudable example of the value of public participation.

It was recognized by participants that conflicts also arise between adjacent ecosystems. Achieving local goals may depend on or conflict with the actions of neighbouring regions. This problem is common-place at an international level where there are sharp boundaries between jurisdictions. This problem may become increasingly acute at smaller-scales as more and more control is given to local residents. How can mechanisms for resolving these conflicts be developed which still support local control over decision-making? Some of these conflicts may be avoided by properly delineating ecosystem boundaries at each scale of interest. Much management currently takes place along boundaries which may or may not reflect ecological, socioeconomic, or cultural realities. Conflicts are more likely to occur where jurisdictional or institutional boundaries do not coincide with natural ecological, socioeconomic or cultural boundaries. A major role for science in ecosystem management is identifying logical management units. The efforts by the province of British Columbia to apply ecosystem classification to management (as presented by Andy MacKinnon and Ralph Archibald), are therefore a very important step in setting logical management units.

Conflicts arise not only among different scales, jurisdictions, and approaches to goal-setting, but also among the types of goals inherent in an ecosystem approach to management. During the workshop, three broad sets of relevant goals emerged: ecological, economic, and social. Conflict occurs when ecosystems are unable to meet all of these goals simultaneously. Where these goals overlap there will be no conflicts, since the goals and objectives from all three perspectives support and complement one another. Indeed, the degree of overlap among these goals may provide one measure of sustainability. Unfortunately, there is currently a large area of non-overlap perceived among these goals.

In the short-term, trade-offs will have to be made among goals. For example, immediate social or economic goals, such as jobs and income may require sacrificing certain ecological goals, such as biodiversity or environmental quality or vice-versa. The challenge will be quantifying these *trade-offs* and assessing their *long-term implications*. Analytical frameworks such as the one proposed in the goal-setting model above (section 5.4) are required for this task. Trade-offs must be assessed not only across sectors, but over spatial and temporal scales. Both social and natural scientists must be involved in assessing these trade-offs. Many participants felt that the workshop could have benefitted from the insights of more social scientists on how to resolve trade-offs. The ultimate choice among goals, however, will remain a political decision involving the relevant publics.

Several workgroups mentioned creative ways for reducing trade-offs. For example, opportunities for multiple-use management, demand management, and increased resource-use efficiency or other technological changes may increase the overlap among goals. In addition, investments in natural and human capital may actually increase the ability of ecosystems to meet more goals simultaneously. Population growth, however, was consistently identified as the greatest threat to reconciling various goals since gains in efficiency are quickly lost to increases in overall demand. In the long term, even greater opportunities for technological, managerial, and social change exist. Ultimately, changes in social attitudes, such as the development of a land or ecosystem ethic may hold the greatest potential for reconciling social, economic, and ecological goals. Jack Vallentyne noted that many young children (ages 6-12) have already adopted a global ecosphere ethic.

6.1.3 Equity and Ethics

Questions of equity arose throughout the workshop: Who speaks for the environment in the goal-setting process? Who speaks for future generations? Jack Vallentyne also pointed out that children have a lot to contribute to ecosystem management. Should they be involved in setting long-term goals which will certainly influence their futures? Who speaks for citizens external to the area for which goals and objectives are being set? Indeed, who is the relevant public? Analytical frameworks which expose the actual trade-offs among goals (in time or space, and by sector) may provide one tool for identifying and resolving issues concerning equity. However, this assumes equal access to information and resources by all participants in the goal-setting process.

6.1.4 Limits to Knowledge and an Abundance of Uncertainty

It was noted at several points during the workshop that our knowledge of ecosystems (including both social and economic systems) is inadequate to permit certainty in the goal-setting process or in fully assessing trade-offs among goals. Indeed, we lack a truly holistic science to support the ecosystem goal-setting process. Several participants stressed that uncertainty needs to be explicitly recognized and incorporated into management decisions. They felt that an ecosystem approach must be adaptive and able to respond to new information or understanding. It logically follows that goal-setting and implementation is an iterative process, requiring refinement as our knowledge increases (as shown in Figure 8). In the face of limited knowledge, some participants advocated the use of a precautionary approach to goal-setting, to minimize the risk of irreversible or catastrophic change. This will require extensive use of risk assessments and monitoring programs which provide quicker feedback regarding ecosystem status. Choosing appropriate indicators for assessing management efforts remains one of the greatest challenges to implementing an adaptive approach to ecosystem management. The EMAP and Green Bay RAP approaches to indicator development (as presented by Steve Weisberg and Victoria Harris, respectively) represent useful organizational frameworks. Also, the presentations of Stephen Woodley, Steve Weisberg, Chris Yoder, Jim Karr, and Trefor Reynoldson described indicators relevant to both ecosystems integrity and management.

Ecosystem goals and objectives also contain implicit assumptions about ecosystem structure and function, and about the existing or achievable states of an ecosystem. An appropriately structured ecosystem approach to management may be used as one means of testing these assumptions and increasing our understanding of the ecosystem. Ralph Archibald and Steve Chatwin stressed the importance of this approach in their presentations.

Our knowledge of societal values is also limited. Many participants raised the need to develop more creative mechanisms for drawing out people's values and for stimulating open discussions about those values. Goals and objectives carry implicit statements of social values. An ecosystem approach must be sensitive to uncertainties regarding the relative weight of those values, adapting as knowledge of social values increases or as those values change. People may not even know the desirability of an envisioned future state until it is actually achieved. Together, the goal-setting process and ecosystem management are on-going processes for articulating and refining social values.

Many workshop participants expressed the importance of a humble attitude on the part of all stakeholders (including scientists). The challenge is to develop goals and management tools which are adaptive, recognize uncertainty, and respond rapidly to change or new knowledge. We must support and encourage diversity in tools and approaches.

6.1.5 Leadership and Vision

Questions about leadership surfaced throughout the workshop. Leadership requires skills and attributes different from what we typically associate with management. The most notable function of leadership is to provide a long-term vision. Management is necessarily more immediate, focusing on short-term crises and keeping the ship on course.

Where does leadership ultimately come from? John Azar noted that leadership is not so much the attribute of a single person or even a single agency, but rather a collection of tasks spread among a group of individuals or agencies. Leadership is required to get the process started. Once the ball is in motion, however, an ecosystem approach should encourage and support the development of leadership skills across a range of participants from a variety of sectors. Environmental leaders should act as role models, encouraging public participation and involvement in both the goal-setting process and the day-to-day management of ecosystems. Further, leaders should promote the establishment of an ecosystem ethic and a sense of ecosystem stewardship.

6.2 Parting Thoughts

The preceding section provided a synthesis of some of the issues raised during the workshop with respect to taking the ecosystem approach beyond this workshop. In the final plenary session, the participating institutions and workshop participants offered some further thoughts on these issues.

6.2.1 Institutional Perspectives

Vic Niemela Regional Director, Environmental Conservation Directorate, Environment Canada

- We are looking in the rear-view mirror to see where we have been, rather than looking ahead to see where we are going.
- We should take the opportunity that FRAP provides for applying the ecosystem approach.
- Pilot projects would provide a useful learning ground.

John Azar Acting Director, Water Quality Branch, Ministry of Environment, Lands and Parks

- Use FRAP money to demonstrate the ecosystem approach and develop the processes and tools.

- We don't have to wait for leadership to come from somewhere else; we want to step up and lead the process ourselves. If we take this route, the ideas will percolate up to the top and across agencies.

- Organizational leadership: use IJC, FREMP as models for Fraser Basin Management Board.

- We need people to champion the process, and to shake things up.

Jim McCracken *Regional Director, Ministry of Environment, Lands and Parks*

- The ideas discussed at the workshop were not really new, we just use different words to describe old ideas.

- It is the technical people who need to undergo paradigm shifts; the public has already shifted.

- Agencies that were not represented at this workshop, such as industry and municipalities, need to be part of the process.

- There seemed to be more emphasis on water resources than terrestrial resources; we need to deal with land-based issues as well.

- The budgetary reality is that plans to move toward a more ecosystem-oriented approach must be done at the expense of existing programs.

- FREMP, FBMB, and Burrard Inlet have good processes in place that might serve as models.

- People need mandates from above for direction on this, because they are too busy dealing with specific issues.

- We need to get various parties together with Tony Dorcey's group. We need to talk the same language, and work towards the same goals, objectives and targets.

6.2.2 Workshop Participants' Perspectives

The final plenary session involved some lively discussion concerning future directions. Further comments were received from a workshop evaluation form. An examination of responses to the form indicated that most participants felt that the workshop was very worthwhile. There was, however, lots of variation in what components were considered to be of greatest value. Both oral and written comments have been grouped into three general areas:

- general strategies to promote the adoption of an ecosystem approach in British Columbia;

- necessary expertise for implementing an ecosystem approach; and

- healthy scepticism and remaining problems.

These ideas are presented only in summary form, since that is how they were delivered.

General Strategies for Adoption of an Ecosystem Approach in B.C.

- We should be integrating the ecosystem approach into the way we manage natural resources in B.C.

- We need to set two fundamental goals: 1) get the ecosystem approach working in the province; and 2) get the idea of an ecosystem approach into the heads of government officials.

- A strategy is a plan to overcome obstacles to achieving a goal. A serious discussion of obstacles was missing at the workshop. What is the strategy to overcome the obstacles?

- We need to take the results of the workshop to a higher level to get results. Higher level people need to briefed, and need to be involved.

- The lack of ecological economics in government thinking/decisions really prevents implementation of the ecosystem approach.

- The difference between ends and means, goals and strategies, values and tools, paradigms and traditional activities should be accentuated all the way through.

- We need to reconvene key persons from the Provincial/Federal agencies. This should be attempted after a brief period of time so that the ideas and concepts raised at the workshop can have time to be clarified.

- We need more case examples to focus the approach. Looking at a more specific geographic location within the Fraser Basin would help.

- The question of institutional change needs to be understood in more detail.

- What are possible ecosystem flags to encourage public understanding? Possibilities: road signs indicating the current number of birds flying by an area of golf courses, or showing current phosphorous levels in lakes threatened by eutrophication.

Necessary Expertise

- We need to harmonize social and ecological goals within the ecosystem - this requires a broader set of skills than were present at the workshop.

- We need a more diversified representation of people (e.g. bringing together more disciplines, including specialists in economic-ecological field, social scientists).

- Restoration ecologists and conservation biologists are required to provide the missing ecological *bottom line* on how much habitat is required to maintain self-sustaining biological communities. We also need their insights on what is possible in terms of restoration of degraded ecosystems, including the removal of invasive species and the loss of key species.

- Problem solving by reduction is a flaw in the way we learn and tackle problems. We need to make changes in the way we train scientists, so as to become more holistic.

- Why is the science culture so reluctant to rely on good judgement? Sociologists and economists don't get hung up on this. Ecological scientists are poor risk takers. Day to day work uses professional judgement and does not require as much data or level of proof.

Healthy Scepticism and Remaining Problems

- Today's flipcharts are probably not that different from flipcharts of workshops 10 years ago, presented under such phrases as "integrated management".

- We don't need to shift paradigms, we just need to get on with it.

- Who speaks for the environment? Until the environment is represented, this approach won't be implemented.

- The definition of "ecosystem" remains a difficult problem.

- We often cannot measure what we need to know (e.g. amount of "critical" habitat). Often we only know less will be worse. Sometimes precise measurement isn't necessary, a "quick glance" will do.

7.0 References

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