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FORMULATING OBJECTIVES FOR MANAGEMENT ON AN ECOSYSTEM SCALE

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Use of Language and Italics in this Document

Where possible, plain language has been used for the benefit of readers unfamiliar with scientific terminology. However, where no plain language synonym exists and use of a particular term (e.g. *transdisciplinarity*) cannot be avoided, or where it is important that the precise meaning of a concept, phrase, perspective or intent be understood, *italics* are used to indicate that an explanation is provided in Appendix 1.

As this document concerns *management* on an ecosystem scale, the word "ecological" has been favoured instead of "*environmental*" to remind users of the importance of considering ecosystem connections, complexities and dynamics in all *management* decisions. These two words are not synonyms. Explanations of *environment* and of an *ecosystem approach* are provided in Appendix 1 in Appendix 3 respectively.

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EXECUTIVE SUMMARY

Once changed, the condition of a particular ecosystem can be very costly, or impossible to restore. The condition of an *ecosystem* is commonly influenced by the decisions and actions of many people. For example, though often small and dismissed as “insignificant”, combined numerous pollution sources and hydrologic changes can profoundly affect a watershed-scale aquatic *ecosystem*.

Unwanted changes within *ecosystems* can be prevented if the ecological implications and consequences of possible decisions and actions are first evaluated. When people decide to influence an *ecosystem* to maintain or achieve a desired condition, they *collaborate* by uniting and managing their decisions and activities in an interconnected and coordinated way. Successful *collaboration* first requires agreement on the desired ecological condition and a clear description of the desired ecological condition and common focus in the form of detailed *management objectives*.

A *management objective* is an explicit quantitative statement which describes the desired state of a particular *valued ecosystem component*. *Valued ecosystem components* are the ecosystem structure/s and functional process/es on which value is placed. These valued components provide the backbone of each *management objective*. *Management objectives* are initially derived from *vision or goal* statements. An objective statement contains a desired target for the *valued ecosystem component* or a temporary qualitative direction of change (such as "decrease" or "increase") if ecological understanding is insufficient to assign a target, and a deadline for success.

The scientific and technical complexity of the subject, the multiplicity of perspectives of individuals and agencies now involved, the desire of these collaborators to evaluate the degree of success in achieving *management objectives,* and many other inter-relational uses made of these objectives, have clarified the need for the advice offered herein.

This document offers advice to *collaborators* responsible for formulating *management objectives* on an *ecosystem* scale. A ten-step process is described intended to be applicable within known boundaries of any ecosystem. Criteria are provided (Table 1) for judging whether the process (Table 2) has been completed. Explanatory information and references cited allows users to appreciate the knowledge and skills required. Fundamental concepts are explained using a watershed scale aquatic ecosystem as an example.

The ten-step process described is both an art and a science, and it requires a practical understanding of "how to get there from here". Though in practice the process is dynamic and requires flexibility, for clarity the ten steps are described in a sequence (Table 2). The process starts with identifying the *ecosystem boundaries* (e.g. a watershed scale aquatic ecosystem), and understanding how that ecosystem is structured and functions. Further steps include identifying the valued structures and functional processes of the ecosystem, and then stating the desired condition of each. The process is concluded when each objective, and all co-dependently linked groups of objectives, satisfy a series of strategic directions, ideals and assessment criteria. The results will be *management objectives* suitably crafted for implementation.

1.0 INTRODUCTION

This document offers advice on how to formulate objectives for managing on an ecosystem scale. This form of results-oriented management within ecosystem boundaries requires close collaborative arrangements to be successful.

1.1 Historical Context for Managing on an *Ecosystem* Scale

The Concept

About 3600 years ago, the Chinese found that deforesting highland areas in a watershed increased water runoff and caused downstream flooding. They had discovered an important relationship: upstream changes can cause unwanted downstream consequences. They then used this knowledge to manage human land use activities more effectively in headwater areas to prevent unwanted downstream flooding and its related effects.

Throughout recorded history, many human activities have been found to have ecological consequences - some wanted, others unwanted. Understanding the ecological cause-and-effect relationships (causality) which exist between human activities and the most likely ecological responses within ecosystems allows prediction - and a choice of alternative ecological futures. A description of the desired ecological future provides the basis for *management objectives*.

Obviously, the concept of *management* on an *ecosystem* scale is not new - but it has come of age. During the last forty years, improved understanding of causality within ecosystems has increasingly allowed for more sophisticated and deliberate *management* of human activities. Management is undertaken to ensure that desired ecological conditions are maintained, existing unwanted ecological consequences are *rehabilitated*, and sometimes to *enhance* desired ecological conditions. Managing human activities to maintain desired ecological conditions through a very long term (Norgaard, 1992) ensures that human activities within an ecosystem are ecologically sustainable (Kumar, Manning, and Murch, 1993). Such maintenance will also make costly post-development *rehabilitation* of desired ecological conditions unnecessary.

A *management objective* is an explicit quantitative statement which describes the desired state of a particular *valued ecosystem component*. *Valued ecosystem components* are the ecosystem structure/s and functional process/es on which value is placed. These valued components provide the backbone of each *management objective*.

Choosing what is, or what is not, wanted within an ecosystem is the central debate to formulating *management objectives*. "Choosing" is based on an understanding of the many implications and consequences of the choices. As noted in 1988 by the World Commission on Environment and Development [Bruntland Commission], "...to anticipate and prevent environmental damage will require that the ecological dimensions of policy be considered at the same time as the economic, trade, energy, agricultural, and other dimensions." These dimensions and agency policies are

considered and integrated within the context of local conditions by collaborators who formulate *management objectives* for a particular ecosystem.

Recent Events in Ontario

The natural boundaries of ecosystems often cross jurisdictional boundaries. Growing concern over unwanted changes to Ontario ecosystems has resulted in increasing numbers of collaborative arrangements among jurisdictions within *ecosystem boundaries* (e.g. on a watershed and subwatershed scale). Large potential cost savings associated with ecologically sustainable development is one of many factors hastening these arrangements.

Collaborative arrangements among jurisdictions often have common needs for advice concerning how to manage on an ecosystem scale. In 1993, the Ministries of the Environment, and of Natural Resources responded to this growing need by jointly released three documents entitled:

- Water Management on a Watershed Basis - Implementing an Ecosystem Approach
- Subwatershed Planning
- Integrating Provincial Water Management Objectives into Municipal Planning Documents

These three documents explain a planning and implementation process used to fulfil *management objectives* within a watershed scale aquatic ecosystem.

The still growing interest among jurisdictions in managing on an ecosystem scale was recognised in statutory changes made in 1996 to the Ontario Planning Act. The Act was amended to encourage municipalities to adopt efficient, cost-effective development and land use patterns for planning community growth in organised areas of the province. Planning Act policies were amended to encourage a co-ordinated approach to deal with issues which cross municipal boundaries (e.g. Policy 1.1.1(e) - coordinated planning within *ecosystem boundaries* using watershed *management*).

In early 1997, a multi-agency Watershed Planning Implementation Project Management Committee completed a three year evaluation of watershed *management* and concluded that watershed *management* could be a locally initiated and community driven process, and that this *ecosystem approach to management* should be supported and encouraged by provincial agencies. The committee reaffirmed that better *management* of human activities to prevent unwanted changes in an ecosystem was desirable and possible. It also recognised that success of this form of management commonly involves the collaborative efforts of many people, businesses and agencies. Gust and Novak (1997) describe collaborators commonly involved in conducting Ontario watershed management projects through the period 1990-95.

The scientific and technical complexity of the subject, the multiplicity of perspectives of individuals and agencies now involved in managing on an ecosystem scale, the desire of these collaborators to evaluate the degree of success in achieving *management objectives*, and the many

important uses made of these objectives, have clarified the need for an explanation of how to formulate objectives for *management* on an ecosystem scale.

1.2 Purposes of this advice

This advice is offered to:

- describe how an *ecosystem approach to management* should be used in formulating *management objectives*

- describe a generic process, some useful strategies, ideals and assessment criteria, as a suggested common starting point for formulating *management objectives*

- ensure that pertinent issues are fully integrated and incorporated into this process, for example:
  - values and interests (e.g. societal values encoded into law, economics...etc)
  - ecological knowledge and understanding including an ability to predict the ecological future
  - ecosystem realities,
  - local *management* needs,
  - limits of technology and practices which could avert unwanted ecological effects, and
  - *management* options for human activities; and to

- ensure that each management objective can be audited for success and that each is linked to corrective measures which may be needed to ensure continued success

The logic, concepts and steps described are intended to be generic and applicable within the known boundaries of any ecosystem. A watershed scale aquatic ecosystem is used to illustrate the concepts discussed.

1.3 Anticipated users of this guide and the knowledge needed

This guide is intended as advice to persons responsible for formulating *management objectives*. It is expected that the resulting objectives will be used in day-to-day decision making by all *managers*.

This guide is intended to promote thought, discussion and suggest a common starting point rather than to be a prescriptive cookbook. It is assumed that users possess:

- general appreciation of what *management* on an ecosystem scale entails

  For example, users interested in watershed/subwatershed scale *management* should be

familiar with the intent and content of the three guidance documents previously mentioned in Section 1.1,

and

- knowledge of valuation concepts and techniques, and of how to assess whether a particular *management objective* is ecologically achievable or verifiable.

Five Appendices, and literature referenced in this document (and in future documents in this series), are provided to assist users who may find they require more knowledge or skills to use the advice offered.

Though diverse knowledge and skills are an asset among users, it is also assumed that some collaborating users possess the:

- depth and breadth of scientific knowledge, technical skills, cross-training and cross-experience needed to be *transdisciplinary*. It is important to note that *transdisciplinarity* is fundamental to the process and required throughout; it is NOT a component which can be added later. See Section 3.2 (particularly step 2 and Table 3) and Section 1.3 of Appendix 5 for more advice on the selection of collaborators.

1.4 Content of this guide

This guide is organised to emphasize the ten-step advice offered in Section 3. To ensure that the advice is not obscured, details are appendicised.

The first and second Sections of this work briefly introduce the subject, some conceptual foundations, and identify management ideals, strategic directions, assessment criteria for judging whether the process of formulation has been completed for each objective. The third Section recommends a ten step process for formulating *management objectives*, and also suggests some criteria for estimating the effort required, and some strategies for allocating this effort.

Appendix 1 provides explanations of some technical terms and concepts used in this guide. The importance of *management objectives* is explained in Appendix 2, and some uses of management objectives in decision-making are listed. Appendix 3 contains an explanation of an *ecosystem approach to management* - a concept fundamental to this work. Appendix 4 describes *management* ideals, and the three strategic directions of *management*. Appendix 5 contains explanations of six criteria used for assessing and judging whether the ten-step process has been successfully completed.

To avoid repeated reference to the appendices, it is assumed that readers less familiar with the subject, have first read and understand all five appendices. These Appendices contain more explanation and definition of the intent of the concepts, and advice and judgement criteria recommended.

Future documents of special relevance to this work are planned. It is anticipated that these will include background documents, case studies, and descriptions of scientific methodologies and techniques needed to assess ecosystem conditions, particularly:

- *Valuation for Managing on an Ecosystem Scale* (further advice on selecting *valued ecosystem components* (*VEC*s))
- *Predicting the Ecological Future* (knowledge required to assess whether objectives are ecologically achievable)
- *How to Assess Success in Achieving Ecosystem Scale Management Objectives* (general knowledge required to assess whether objectives are verifiable)
- *Design of Sampling Programs for Assessing Success in Achieving Ecosystem Scale Management Objectives* (detailed knowledge required to assess whether objectives are verifiable - and how to do this)

2.0 SOME FOUNDATIONS

It is necessary to fully understand some useful concepts, principles, and evaluation criteria to successfully complete the ten-step process described in Section 3.

2.1 An ecosystem approach to management

An "*ecosystem approach to management*" means *management* of human activities at an ecosystem scale (e.g. such as within watershed scale boundaries of an aquatic ecosystem, as described by Likens (1984)). The "approach to management" is results-oriented because it seeks to specify a desired condition of an ecosystem, and maintain or achieve it by managing human activities and practices which could affect success.

The thought process leading to an *ecosystem approach to management* requires use of *transdisciplinarity* (a purposeful and intentional blurring of disciplinary boundaries). Throughout the ten-step process recommended in Section 3, *transdisciplinarity* should be used to share and merge perspectives and thereby fully integrate ecological knowledge and understanding, ecosystem realities, local *management* needs, and technology and practices which avert unwanted ecological effects.

Transdisciplinarity requires preparation. Collaboration to achieve common objectives on an ecosystem scale unites *management* decisions and the subsequent actions of many individuals and agencies, and bestows responsibility for preventing unwanted ecological change on those collaborators who otherwise may unknowingly cause it. This close level of co-operation requires collaborators to first reach consensus on a common set of underlying values and in doing so, fully integrate their interests.

2.2 Assessment of draft *management* objectives using principles and criteria

Management objectives should fully satisfy the hierarchal ideals, and criteria listed in Table 1.

As these are tests of whether the recommended ten-step formulation process described in Section 3 has been completed, it is very important that the intent and meaning be fully understood, and be kept in mind throughout the process.

TABLE 1	**Summary of the strategic directions, ideals and assessment criteria which should govern the final number, form and content of management objectives (see Appendices 4 and 5 for further explanation).**

STRATEGIC DIRECTIONS OF *MANAGEMENT*:

(1) **maintenance and protection** of ecosystem structures and functional processes thereby preventing unwanted ecological changes

(2) **rehabilitation** of ecosystem structures and functional processes, and/or

(3) **enhancement** of ecosystem structures and functional processes

IDEALS:

" *Management* ideals should be:

(1) **effective**

(2) **efficient**

(3) **fair**

" Human activities are managed to realize *management objectives*

ASSESSMENT CRITERIA:

Management objectives should be:

(1) **clearly worded**

(2) **achievable**

(3) **verifiable**

(4) **ecologically complete**, and a party should be

(5) **accountable** for success.

3.0 A PROCESS FOR FORMULATING MANAGEMENT OBJECTIVES

Management objectives can be formulated in ten steps (Table 2). The logic of the process is uncomplicated. After determining the reasons for the present condition of the ecosystem, the process establishes a general description of the desired condition of the ecosystem. These *visions* or *goals* provide only a qualitative description. The remaining steps seek to increase the specificity of *visions*/*goals* by translating them into statements of measurable conditions.

TABLE 2 Steps for formulating management objectives

STEP 1 *Identify the boundaries of the ecosystem (e.g. a watershed).*

STEP 2
(a) Form the initial collaborative team. Determine the individuals, groups and agencies, whose management decisions or actions have the potential to most greatly affect the condition of the ecosystem and who wish to collaborate management.

(b) Collaboration requires negotiation: agree on a process for negotiating agreement among collaborators.

STEP 3 *Assess the past and present condition of the ecosystem.*

STEP 4
(a) Define causality: assess how human activities have likely changed the condition of the ecosystem.

(b) Determine if the initial collaborative team is sufficient to manage human activities given the apparent values and the type and direction of historical changes in the condition of the ecosystem. Identify and screen new candidates.

STEP 5 *Determine the desired condition of the ecosystem. Use a facilitated public forum to further refine the assessment by discussing interests and values, to identify a vision statement for each value, and to help identify valued ecosystem components.*

STEP 6 *Form a final collaborative team of implementers.*

STEP 7 *Use all previous information to formulate an initial set of objective statements. Organize them into ecological groupings so dependencies are made obvious.*

STEP 8 *Organize objectives into the three categories (i.e. maintenance, rehabilitation, and enhancement). Evaluate each objective, and ecologically co-dependent objectives, against the strategic directions, ideals and assessment criteria contained in Table 1. Objectives are complete and the process is finished if these are satisfied and when there is no possibility of misinterpretation - exit the steps.*

STEP 9 *Refine and tailor objective statements which do not satisfy step 8. Determine data or knowledge needed to refine objectives which do not satisfy the criteria and principles contained in Table 1. Prioritize these needs and decide what must be collected. Collect it.*

STEP 10 *Return to STEP 8.*

This translation will ensure that each objective is fully understood and will allow the uses described in Appendix 2 - particularly the tracking of success, so that *management* decisions and actions can be adjusted to ensure that each objective is fulfilled.

An *ecosystem approach to management* founded on *transdisciplinarity* is used throughout to integrate values and institutional requirements with understanding of local *ecosystem* realities and *management* needs, as well as technological realities.

The number of *management objectives* derived using this process will depend on:

- the number of *vision* and *goal* statements which are translated
- the kinds and number of *ecosystem* structures and functional processes actually valued (influenced by the valuation perspectives used)
- the type and degree of changes desired in valued *ecosystem* structures and functional processes, and the number of ecological dependencies. For example, relatively fewer management objectives may be required in ecosystems where emphasis is placed on maintenance and protection of the existing condition rather than on rehabilitation and/or enhancement.

and,

- whether draft *management objectives* satisfy the strategic directions, ideals and criteria in Table 1.

3.1 Evaluating the adequacy of a *management* objective statement

The strategic directions, ideals and criteria listed in Table 1 (and discussed in Appendices 4 and 5) are applied to each management objective to assess whether the ten-step process has been completed.

3.2 Ten steps to satisfy *management* strategic directions, ideals and criteria

Table 2 outlines ten steps for formulating *management objectives* on an ecosystem scale. An explanation of each step is provided in this Section.

As previously mentioned, to ensure brevity, terms and concepts used in this Section are explained elsewhere in this document, or in cited references. It is assumed that users fully understand this foundation material prior to using the ten steps.

STEP 1

Identify the boundaries of the ecosystem (e.g. a watershed).

An *ecosystem* has three spatial dimensions and is dynamic. Boundaries should be considered using a variety of space and time scales. For example, a watershed scale aquatic ecosystem includes all surface and ground water which drains to a topographically defined catchment. The condition of an ecosystem changes with time, as may its structures and functions (e.g. seasonally flooded areas used as fish spawning areas). It is very important that changes with time be included in any future assessment.

STEP 2

(A) Form an initial collaborative team. Determine the individuals, groups and agencies, whose management decisions or actions have the potential to most greatly affect the condition of the ecosystem, and who wish to collaboratively manage human activities.

Without the proper preparation, this step can be the most awkward due to an initial shortage of knowledge, information and analytical skills, and unfamiliarity with the multiplicity of organisational, logistical, scientific and technical issues which will likely be encountered (e.g. see Montgomery, Grant, and Sullivan (1995)). Start-up considerations will no doubt include a great deal of homework. For example, homework can include appreciating the knowledge and skills needed for ecosystem assessment, as well as understanding the role which values will play in moulding *management objectives*. Bolling (1994) offers some good organisational and tactical advice to help users anticipate and move beyond many start-up difficulties. For example his advice addresses the need for commitment, finding partners, establishing an organization, raising money, recruiting technical people, hiring a director, planning a campaign, building public support and getting it done. Users of Bolling's advice should, however be aware that his treatment of the interplay between *goals, management objectives*, the collaborators needed, and their needs is rather cursory. His advice narrowly assumes that users are concerned with only a single issue or with a few general goals - and also that users are ignoring unwanted *cumulative* changes to ecosystems. Clearly, use of an *ecosystem approach* requires a longer-term commitment, and more complex effort - often by more collaborators than that assumed by Bolling. These organisational and collaborative differences will become apparent as the detailed work of translating *goals* into *management objectives* proceeds.

Select an initial group of collaborators after screening prospective candidates using criteria listed in Tables 1 and 3, and considerations discussed in Appendix 5. In most instances scientific and technical knowledge, and tactical/operational experience and skills will be important to completing the ten step process - keeping in mind the importance of *transdisciplinarity*. For example collaborators with specialised knowledge and experience, expertise, skills and strengths in (but not necessarily limited to) the following areas should be considered:

Disciplines (ways of knowing)

- ecosystem ecology (e.g. if formulating watershed *management objectives*; aquatic ecosystem ecology)
- other life sciences (eg. fish ecology, plant ecology,... etc)
- hydrology (eg. hydrogeology, limnology... etc)
- [resource] development sciences (e.g. engineering, planning, fisheries management, wildlife management, forestry management, agri-sciences, ...etc)

Skills

- valuation (not limited to monetization)
- monitoring program design
- environmental sampling and analysis
- data management

- principled negotiation/conflict resolution
- education
- facilitation
- organization

TABLE 3 Some considerations for screening prospective collaborators with varying capabilities

- **Context and emphasis of the decisions and work needed**
  To satisfy the directions (e.g. prevention), ideals (e.g. fair) and criteria (e.g. accountability) listed in Table 1, who should be included in the group of collaborators?

- **Values/compatibility of interests/willingness to negotiate**
  Given a number of choices, will the desires of a particular candidate likely be complimentary or mutually exclusive with those of the existing partnership (consider criteria described in step 3(B)? If exclusive, can compromise be reached? If not, examine why and reassess.

- **Collaborator and implementor**
  Will the person/agency formulating an objective/s also be the implementor (see step 4(b))? This should guarantee accountability.

- **Legal responsibilities**
  Most laws embody explicit management objectives. Compliance is therefore legally required or can be compelled by law or legal instruments. Is a candidate responsible for interpreting and/or enforcing pertinent federal, provincial or municipal laws? Could the candidate enact by-laws to compel compliance with management objectives not presently encoded into law?

- **Scale of collaboration needed**
  Have the vision/goal statements been fully translated into *management objectives* (step 7)? New *management objectives* may need new collaborators.

- **Complexity of collaboration**
  Do the responsibilities of collaborators fully address the ecological linkages between *management objectives*? (Each is responsible for a particular piece, or pieces, of the ecological puzzle - see Appendix 5; Ecologically Complete.)

- ***Management* expertise**
  What in-house scientific capacity does the candidate possess or have access to?

- **Scientific and technical knowledge and expertise**
  Does the candidate have sufficient relevant experience and relevant training, knowledge and expertise to help guide group members who have skills in other areas? (e.g. to ensure *transdisciplinarity*, or to assess the verifiability each management objective)

- **Local knowledge**
  Does the candidate possess local knowledge (e.g. traditional ecological knowledge) useful to establishing what ecosystem components are valued and/or to assess the condition of these *valued ecosystem components*? Can the candidate provide facts to support the assessment so that others can share the assessment?

It is also very important to anticipate the need for accountability - a need which can be satisfied by ensuring that each person formulating *management objectives* speaks for their organisation or agency, and will be directly accountable for achieving specific objectives.

Consider the human agents of change in your ecosystem, for example:

- laws, regulations, policies, economic incentives, the agencies and persons responsible for administering these
- industries and other land and water developers (e.g. manufacturing, hydroelectric producers...etc)
- agriculture
- forest harvest and silviculture

Are the decisions and/or activities of a particular agency, business, group, or individual/s affecting the condition of the ecosystem? If not now, what of the foreseeable future? If you are uncertain of the answers, some useful suggestions are provided in steps 4, 5 and 6.

The sophistication of the organization will increase as the needs become more apparent - focus will increase. It should become easier to acquire more support and to recruit more collaborators, and this team will evolve in response to the focus. This evolution is anticipated in steps 3 and 5 which prompt ongoing review and possible revision of the membership.

The duration of a collaborator's involvement will depend on such things as the characteristics of the work needed, and on the need for a collaborator's ongoing accountability to continued success in achieving a particular objective (e.g. by monitoring and using the results to adjust management activities to ensure continued success). The effort needed is discussed in Section 3.3.

(B) Collaboration requires negotiation: agree on a process for negotiating agreement among collaborators

Collaborators should discuss whether they are interested in the ecological sustainability of human activities. Mutual agreement on common values is needed to;

- achieve ecological sustainability of human activities, and to
- conduct *transdisciplinary* work fundamental to an *ecosystem approach to management*.

When:

- a large range of values is initially held,
- ecosystem complexities are great, or
- logistical and organisational arrangements are very challenging

increased potential for disagreement among collaborators should be anticipated. It would be shrewd and prudent to adopt a process for negotiating agreement among collaborators.

The ideal negotiation process should create a relationship among participants which facilitates dealing with differences and issues on their merit. The process should avoid conflicts between interests which may result in the taking of positions and sides, with little understanding between. It should help participants avoid unbending entrenchment which inevitably leads to confrontation, conflict and division. It should focus on the ecological consequences of negotiated agreements. It should seek synergy of human activities within the limitations of an ecosystem, rather than impose trade-offs on the desired condition of an ecosystem.

Principled negotiation (Fisher and Ury, 1981; Fisher and Brown, 1988; Dale, 1991) satisfies these needs and should be used to seek consensus and agreement.

Candidate collaborators should be prepared to agree to use the following criteria (Wood and Chesters, 1989; Dale, 1991):

- All interested parties should be involved.

  This should lead to permanent solutions rather than temporary solutions usually associated with coalition building and exclusion of some parties.

- The interested parties should feel a roughly equivalent need to resolve the problem.

- Participants representing an organization should have the authority to commit their organizations to solutions agreed upon.

- Operating procedures should ensure that all parties feel they are equally empowered in the negotiation process.

  The focus should be on seeing merit in proposed solutions. The playing field should be level between negotiators with financial abilities of each negotiator, access to expertise,...etc. not allowed to interfere.

- Participants should be committed to multilateral rather than unilateral solutions.

  Because no single participant owns the entire *management* process, no party should attempt to impose its ideas on the rest. Agencies may be concerned about statutory (legal) accountability. Statutes reflect values. Latitude for interpretation and tailoring of these values into *management objectives* at an ecosystem scale should be discussed.

- Participants should have an explicit concern for each group's views and interests, and the desire to reach decisions with which all participants can abide.

Principled negotiation of *management objectives* includes:

- agreeing on the agenda

- separating personalities from the ecosystem issues
- focussing on ecosystem issues, not on interests or on jurisdictional positions. Ways and means include:
  - seek to see the problem from the other point of view; be rational, communicative, trustworthy, understanding, and non-threatening
  - identify the key issues and concerns involved - in a way acceptable to all parties (e.g. evaluate the relative importance of each issue and allocate time accordingly)
  - identify what ecological results will constitute a fully acceptable solution (e.g. restate the objectives in a more acceptable way)
  - inventing options for mutual gain
    - anticipate rather than react
    - catalyse creativity (e.g. if only two alternatives are apparent (i.e. yours and the wrong one), look for a synergistic third)
    - establish who is doing what (e.g. who is achieving each management objective)

In practice, negotiation should conclude with acceptance of the *management objectives* by all participants. Given all the preceding negotiation criteria, acceptance means either the support of, or lack of opposition by, collaborators. Acceptance does not necessarily mean that each party believes that the decision is the best one possible relative to their starting point, but it could instead indicate a shift in the underlying values held (see Dale (1991) for a good discussion of this point).

STEP 3

Assess the past and present condition of the ecosystem identified in step 1.

Explore causality in a way that will later (step 4) be used to identify cause-and-effect relationships of importance to present and future management decision-making. Of particular interest are human-cause-and-ecological-effect-relationships, both historical and present-day. Seek to understand why the condition of an ecosystem changed, and how it changed. It is also necessary to determine how much the condition of an ecosystem has changed so you can identify and scope the opportunities for rehabilitation.

- Assemble only the existing information and data needed for this initial assessment. Become aware of the history of changes in the ecosystem's condition - and of how these changes may have been linked with human activities.

- Be discerning; the intent is NOT TO ASSEMBLE ALL EXISTING INFORMATION in great detail. Intuition based on a general relevant knowledge of causality is needed to complete this step with the greatest efficiency and economy. If the appropriate homework has been completed in step 1, the obvious quandary of "not knowing what you need because you don't know why" will have been averted. This is a good time to seek the assistance of an ecosystem ecologist.

  Throughout, remember that this ten step process is dynamic and allows more information

to be collected at any time. For future reference, become aware of what is known and where this information can be obtained. Survey what pertinent information and data is available, where it can be found (e.g. contact names and telephone numbers of persons and agencies holding data of interest, reports, books,...etc) and what form the data is in (e.g. paper records, electronic,...etc). Collect the most relevant data. (Deciding what is pertinent and relevant will no doubt require intuition and insight).

- Perform a reconnaissance survey of the ecosystem by touring it. Become familiar with the ecosystem; field-verify the impressions and insights resulting from the previous information/data search, and gain some first-hand impressions while assessing its present condition.

- Determine what human activities have occurred, are occurring, or are proposed and are likely in the foreseeable future.

- Determine why these human activities are occurring, and may occur. Identify existing mechanisms which promote, dissuade, regulate or otherwise influence these activities (e.g. laws, regulations, policies, traditions...etc). Determine who or what is responsible for these influences. Determine the existing *management objectives* - explicit or implicit - which have led to these influences.

- Understand these influences, their roots, how they work, their strengths and weaknesses, and who is responsible for them. This knowledge should be used to help refine the list of collaborators, and in later steps (e.g. in assessing the achievability of a proposed management objective, and in understanding causality (step 4), in understanding how collaborators can be effectively united in an *ecosystem approach to management*,...etc). These influences are some potential mechanisms for implementing *management objectives*.

- In a general way, assess the structure and functional processes of the ecosystem, and determine which ecological linkages and interactions were likely involved in producing the present condition of the ecosystem.

- Assess which ecosystem structures and functional processes were historically valued (*valued ecosystem components*) and which ones now appear to be actively valued, or are taken for granted (passively valued). From step 2, remember the importance that perspective plays in valuation. Determine if the historical relationship between value and ecosystem condition has changed. Assess if the human activities in the ecosystem seem compatible with the values and the *desired ecosystem condition* (i.e. desired condition discussed by initial collaborators in step 2). Which human activities were, are, and will likely be incompatible with the values held and with the *desired ecosystem condition*?

STEP 4

(A) Define causality: assess how and what human activities have likely changed the condition of the ecosystem.

Using general ecological knowledge, comparative knowledge of similar ecosystems (e.g drawn from the literature), historical knowledge of the ecosystem, and professional judgement, assess how human activities may have already changed the condition of the ecosystem. You may need to revisit steps 2 and 3.

(B) Determine if the membership of the initial collaborative team is sufficient to manage human activities given the apparent values and the type and direction of historical changes in the condition of the ecosystem. Identify and screen new candidates. Review the list of collaborators.

An *ecosystem approach to management* requires collaboration of many agencies and individuals. An ecosystem approach and "system thinking" is needed to address this issue. Remember that the collaborative team will have a long-lasting influence on the degree of success in achieving *management objectives*. Does the present team structure reflect what is needed to manage the human activities which appear to be affecting valued ecosystem structures and functional processes (i.e. *valued ecosystem components* of the immediately preceding step)? Review the team structure and consider the;

- results of the assessment in step 3
- conclusions about causality and the role which one set of values appear to have played, and are presently playing, in human activities,
- decisions and human activities not congruent with another set of values arising from knowledge of unwanted effects, and
- *management* directions needed to make these decisions and activities congruent
- recruiting suggestions offered in step 2 and in Table 3, and
- the need for acceptance of a negotiation process (step 2(B)).

STEP 5

Determine the desired condition of the ecosystem.

Use a facilitated public forum to further refine the assessment by discussing interests and values, to identify a vision statement for each value, and to help in later identifying valued ecosystem components.

Steps 1 - 4 are, in part, the homework needed to properly frame questions directed to the general public - the answers are needed to complete this process. Having completed these four steps, you will have a good idea of what has gone on, and is presently happening in the ecosystem. It is now time to formally re-examine the draft pre-supposed values which have guided much of the process to date - and affirm, supplement and/or change them using the public forum as a sounding board. The tangible results from this forum will be *vision* statements.

Techniques for use in public consultation and consensus building have been described in a variety of publications (e.g. Pinkerton, 1991; Ontario Ministry of the Environment and Energy, 1994). Keep in mind the expectations of the attending public (e.g. see Ryan, (1993)).

Who should attend the meeting? You are seeking to understand the values of other persons and agencies/organisations concerned about the condition of the ecosystem, as well as of those with the ability and authority to manage human activities within the ecosystem. All the initial collaborators should be present and involved in the meeting. An ecosystem ecologist, who participated in steps 1 through 4 and who is familiar with the ecosystem in question, should aid the facilitator in directing discussion of ecological elements (e.g. ecosystem structures and functions, causality, predictions of future changes,...etc).

At the public forum, relate what you have done to date, and what you know of the ecosystem. Highlight the human-cause-and-ecological-effect (causality) relationships you have discovered or suspect. Explain the role which human values play in managing human activities and illustrate with examples from your own research. Explain how producing *vision* statements will help you uncover the values presently held.

Determine the interests and values of the attending public. For example, inquire as to the present and desired uses of the ecosystem. Use the public forum to make vision statements fit together, ecologically. Use principled negotiation to reach a consensus if some interests and values ecologically conflict (e.g. deforestation with no hydrological change).

Word each *vision* statement in a way which both reflects the public's expectations of *management* (see Vaske, Donnelly and Shelby (1993) for some methods for deriving these normative standards), and describes a broad brush ideal (e.g. "We want a clean river"). Derive a simply worded list of reasons for these expectations, including any public uses made of the ecosystem. Map the location of these uses. Tabulate each *vision* and details of the related uses. Where possible, identify ecosystem structures and functional processes related to each *vision*.

Examples of *visions* for an aquatic ecosystem and simple answers to the question "why?" include:

- "green"
  - ecologically connected to maintain functional processes
  - productive
  - self sustaining
  - natural
- diverse
  - variety of habitat
  - rich variety of native species
- aesthetically pleasing
- accessible
- educational opportunities
- clean
  - fishable, including the catch is safe to consume
  - swimmable
  - drinkable

Where possible, broaden the discussion of values to include related ecosystem structures and functional processes. Explain the relevancy. In general terms, determine a value-based consensus of the desired condition of the ecosystem. Try to identify *valued ecosystem components*.

After the public meeting, re-evaluate the accuracy and adequacy of the initial assessment of the ecosystem (steps 2 and 3). Is more consultation needed? Are there sufficient collaborators?

STEP 6

Form a final collaborative team.

Re-apply the screening considerations contained in Table 3 and described in step 4 to the present group of collaborators. Establish the final membership of collaborators.

STEP 7

Use all previous information to formulate an initial set of objective statements. Group them so ecological dependencies are made obvious.

Use the advice offered in Appendices 4 and 5 to guide the content and structuring of each management objective.

The *vision* statements (step 5) provide information about public values and also suggest which ecosystem structures and functional processes are valued. Use the *vision* statements to create a list of these *valued ecosystem components*. Each *valued ecosystem component* will be at the core of a management objective statement. Each objective statement should contain a desired target or temporary *vector*, and a deadline for success. State each management objective in a way which satisfies the management ideals and criteria listed in Table 1 and discussed in Appendices 4 and 5.

It is important that accountability and responsibility for objectives be clear. When success in achieving objectives is ecologically dependent on success in achieving other objectives, make this obvious by organising these objectives into interlocking "dovetailed" groupings.

STEP 8

Organize objectives according to the three strategic directions (i.e. maintenance, rehabilitation, and enhancement) of management.

Evaluate each objective, and groups of ecologically co-dependent objectives, against the strategic directions, ideals and assessment criteria contained in Table 1. Objectives are complete and the process is finished if these are satisfied and when there is no possibility of misinterpretation - exit the steps.

Consider the advice offered in Appendices 4 and 5.

STEP 9

Further refine and tailor objective statements which do not satisfy step 8.

Determine data or knowledge needed to refine those objectives which do not satisfy the ideals, strategic direction and criteria listed in Table 1. Prioritise these information needs and decide what must be collected. Collect it.

STEP 10
Return to step 8.

3.3 Effort needed to formulate management objectives, and some useful strategies

In general, the effort needed to formulate *management objectives* can be justified based on the intended uses of the objectives (see Appendix 2 for suggestions). The effort needed can be estimated within categories and ranked using a relative scale.

A common scheme should be used so that comparisons of effort can be made;

- among collaborators,
- between the strategic directions of *management*, and
- among ecosystems (if deciding which ecosystems, among many in a jurisdiction, should be dealt with first)

Some categories of effort include:

- scoping, acquisition and synthesis of transferable lessons learned in similar ecosystems (synoptic knowledge), existing knowledge of the ecosystem (step 3), and new knowledge (step 9). Uses of this knowledge include:
  - determining historical conditions in the ecosystem,
  - comparing present conditions in the ecosystem to these past conditions,
  - understanding causality to determine which human activities are linked to what ecosystem conditions
  - determining which human activities can, and should be managed
- formulating early draft *management objectives* (steps 2 and 3)
- determining collaborative arrangements needed (steps 2 and 4, 5 and 6)
- facilitating the process of formulating *management objectives* (all steps - particularly step 5)
- iteration until the elements of Table 2 are satisfied (steps 8, 9 and 10)

Much of the effort needed to formulate *management objectives* will be linked to data needed to assess such things as the structure and workings of an ecosystem, the past and present state of the ecosystem, understanding causality, and the data needed to predict the ecological future. Some useful points to consider are listed in Table 4.

Knowledge, good research skills, forethought and careful selection of the information needed to guide the process of formulation, anticipation of future information needs, and the ability to innovate can greatly contribute to reducing effort expended and the cost of information collection and analysis.

It is also important to consider why information is needed, and the sort and rigour of analysis intended. These two factors should be used to judge the type, and aspects such as the quantity and quality, of information sought. For example, the sort of information needed to convince a candidate that his or her help is needed in a collaborative

TABLE 4 Some points to consider when assessing effort needed to formulate management objectives. It is assumed that the user has some prior general knowledge of what sort of *management* may be needed within the ecosystem/s of interest.

! POTENTIAL FOR UNWANTED CHANGES (LOSS OF *VALUED ECOSYSTEM COMPONENTS*)

Does the ecosystem contain valued ecosystem structures or functional processes which may be at risk if *management* opportunities are missed? If so, what is the urgency of actions needed (e.g. scale of perturbations in space and time)?

! IS REHABILITATION POSSIBLE?

If opportunities for maintenance are lost, and unwanted changes occur, is restoration possible? Is only rehabilitation possible (i.e. full restoration may not be ecologically possible)? What are the values which will be lost? What is the duration of the loss?

! IS REHABILITATION AFFORDABLE?

Add the values lost to the monetary cost of rehabilitation and restoration. Contrast the cost of the effort needed to maintain values with the value/s lost through inaction.

! FEASIBILITY OF *MANAGEMENT* ON AN ECOSYSTEM SCALE

DIFFICULTY IN ACQUIRING PERTINENT INFORMATION
Decide what sort of information is needed, and the level of detail necessary. Is this information already available from prior work in the ecosystem (e.g. within a watershed; subwatershed *management* plans or *management* strategies, information about ecologically sensitive areas such as ANSIs or ESAs, information held by special interest groups or volunteers, resource mapping, master plans, academic research, published or unpublished literature...etc)? Can this existing information be readily compiled into a useable form? Can new information be readily obtained (e.g. results of other ongoing work in the ecosystem might be co-opted and used)? Are there any synoptic similarities between smaller ecosystems within a larger ecosystem (e.g. small subwatersheds within the same eco-district/region may be less complex)?

SCALE OF THE ECOSYSTEM
What is the relationship between the scale of the ecosystem and the degree of difficulty in obtaining useful information? (e.g. a very large watershed with many subwatersheds contributing)? What is the relationship between the complexity of the ecosystem and the degree of difficulty in obtaining useful information?

POOL OF AVAILABLE RESOURCES
What is the relationship between the resources available (e.g. expertise, person years, fiscal resources...etc), and those needed for formulating *management objectives*?

PARTNERSHIPS
Consider what collaborative partnerships are possible within the ecosystem. Is discussion necessary to explain why *management* on an ecosystem scale is needed? Once forged, are these partnerships fully capable of dealing with all categories of *management objectives* (e.g. maintenance/protection/prevention, rehabilitation and enhancement)?

EXTENT OF PARTNERSHIPS NEEDED
Are many partnerships needed within an ecosystem (many voices in the chorus)? What is the potential for conflict among collaborators? Do many jurisdictional boundaries cross the ecosystem of interest? Can partnerships be more easily forged if an ecosystem is bounded by a single jurisdiction (e.g. a watershed within a single municipality may require resolving fewer conflicts)?

PROBABLE SPEED OF SUCCESS
Where achieving *management objectives* requires very close collaboration among partners, are there any pre-existing hurdles which must first be modified or eliminated before the collaboration can proceed (e.g. existing by-laws, incentives...etc)?

OPPORTUNITIES TO MANAGE HUMAN ACTIVITIES
What opportunities are there to manage human activities?

! TRANSFERABLE BENEFITS

Are there transferable benefits from formulating *management objectives* in a particular ecosystem which will reduce the effort needed elsewhere (e.g. co-production of products and training materials useful in other similar ecosystems)?

arrangement will differ from the detailed assessment information needed by that collaborator to establish management *targets* within the ecosystem.

To ensure economy, only information which is absolutely necessary should be gathered and analyzed. There are some exceptions to this advice - and there are often some innovative ways to reduce the effort and cost of these exceptions. For example, where logistical costs are very high, such as in a northern watershed, additional information or environmental samples surplus to immediate needs could be opportunistically gathered - if likely future needs are envisioned. Why collect more information or samples than what is immediately required? Forethought and good planning can reduce the number of trips (i.e. logistical costs are often very large in remote areas) and over-sampling can actually reduce the amount of time, effort and costs expended on the field work. Though surplus to your immediate needs, storable environmental samples can be held, allowing costly laboratory analysis to be deferred until the need is clearly demonstrated as information needs become clearer.

Effort put into preparatory research (e.g. library time, networking time,...etc) will pay big dividends by helping to scope, focus and make actual information needs more evident thereby avoiding the costs of confusion. It is important to resist judging the researching of known facts and relationships as "drudgery" - while viewing the collection of new data as "glamourous". "New data" may be unnecessary and a costly error. Recognise the existence of potentially expensive "learning curves" among collaborators and try to conserve your project resources by finding less time-consuming and expensive ways to help them self-educate. Start by capitalizing on what is already available. Needed information or data may already exist. In addition, researching examples from other ecosystem scale work can help you educate fellow collaborators, deduce your needs and identify possible sources of existing data (e.g. held by a particular government agency). It may only be necessary to collect and analyze a small amount of new information or data to "round out" understanding of causality. It is not uncommon to find out that a lot of pertinent information and understanding can be readily, and inexpensively obtained.

One way of reducing effort and cost is to determine what you will likely need before embarking on the quest. An experienced ecosystem ecologist can supply some rapid and practical insights to help guide the process of researching, scoping and screening, anticipating, acquiring, analyzing and interpreting information. For example, general understanding of the linkages between specific human activities and the subsequent condition of an ecosystem (i.e. "causality" described in steps 3 and 4) is necessary to help scope the information needed within your ecosystem. Without this guidance, and if faced with a steep "learning curve", expect to increase effort and cost to directly acquire this knowledge. Also expect to spend time learning where and how to access this information and also in doing a lot of reading. For example, many causality relationships are already well described in freely available literature (e.g. scientific journals, technical reports, books, manuals, internet sites, *management* plans for similar human activities in similar ecosystems...etc). Without this assistance, expect to spend significantly more time researching many related issues such as predicting the ecological future, monitoring program design and sampling protocols. While acquiring experience in this form of trial-and-error learning, also expect that you may make costly mistakes and ecologically unrecoverable errors.

Sometimes the effort needed to formulate *management objectives* exceeds the capabilities or budget of collaborators. One way of dealing with this problem is to prioritise the three strategic directions of *management* (Table 1) and narrowly focus the limited resources of collaborators by:

- formulating objectives within one of the three strategic directions of *management* (e.g. the maintenance/protection/prevention category). Objectives in the other two *management* categories (i.e. rehabilitation, or enhancement) could be drafted - and though they may not fully satisfy the criteria in Table 1, these could be completed as organisational resources become available;

and/or

- within each ecologically linked group of *management objectives* (keeping in mind hierarchical dependant relationships and cross-linkages) reduce the number of *management objectives* that will be considered.

Jurisdictions, such as municipalities, often contain many ecosystems (e.g. subwatersheds). Within strategic *management* directions, the effort necessary to formulate *management objectives* can be estimated and compared among ecosystems, and prioritized among ecosystems.

4.0 CONCLUSIONS

Management objectives are quantitative expressions of *goals/visions*. *Management* assessments, decisions and activities based on these objectives are results-oriented. As human activities are often the cause of unwanted changes to ecosystems, prior knowledge of the expected consequences is used to screen and judge the suitability of human activities. In addition, each objective provides a *manager* with a carefully preconceived "metre stick" to use in tracking the degree of success. Knowing the degree of success in turn provides the basis for decisions about the follow-up corrective actions needed.

The collaborative effort and care taken in completing the suggested process for formulating *management objectives* will be rewarded by improved unity among collaborators, more harmonious *management* decisions within and among jurisdictions, increased emphasis placed on preventing unwanted problems, ensured synergy of human activities within ecosystems, and ultimately more cost-effective decision-making.

Success in achieving *management objectives* can ensure that the broader goal of ecologically sustainable human activities within an ecosystem is attained.

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APPENDIX 1

EXPLANATION OF TERMS AND CONCEPTS

♦ *Adaptive management* (Holling, 1978) is learn-by-doing management. Lessons learned can be used to improve decision-making needed to achieve a particular management objective, or to craft a measurable target (e.g. a specified amount of change) to replace a formerly incomplete management objective containing only a *vector* (an unspecified amount of change in a preferred direction; for example, a reduction in the loading of a particular contaminant to an aquatic ecosystem).

Tactics used in adaptive management are important because learning-as-you-go can have some pitfalls. Among these are the possibility of unwanted permanent ecological changes, and high costs of rehabilitation. Where understanding is imperfect, there are usually two options. Improve understanding of the local situation before making decisions or substitute synoptic knowledge from similar ecosystems and situations elsewhere as a temporary surrogate. In either instance, it will always be prudent and advisable to err on the side of caution. This will allow you to ensure that the consequences of any errors in judgement are kept small and hopefully correctable thereby maintaining options and opportunities to learn after decisions are made.

♦ Though *collaboration* has no synonyms, the Oxford Dictionary (Allen, 1990) provides two distinctly opposed meanings. The first of these - "working jointly" - is the meaning intended in this work. Herein, "collaboration" refers to agencies and individuals willingly making their efforts complimentary and working together as a team toward explicit, often ecologically connected and co-dependent, management objectives.

Collaboration often requires altruism.

Collaboration is necessary to achieve ecologically linked *management objectives*. The fatalistic alternative (i.e. people making the "right" decisions for often the "wrong" reasons) leaves too much to chance. Commonly held values are the ideal “glue” needed to closely bind a collaborative effort and turn it into a team effort.

♦ *Command and control* refers to a prescriptive regulatory scheme based on the setting and enforcement of procedures and standards. The strengths of the structures and tools of traditional governance reflect this approach to managing.

Unfortunately, a weakness of this scheme is the disempowering atmosphere which results when persons come to believe that a central agency can be solely responsible for ensuring ecologically appropriate behaviour - everywhere. Why should such a strong system be disempowering? A sense of personal responsibility for one's own actions is somehow mentally transferred to a central agency - and is thus lost by individuals. A problem to which an individual may be contributing is then thought of as the responsibility of someone else. Using an analogy, consider the modern quandary of insufficient numbers of police available to enforce command and control laws. The old adage "If you are not part of the solution, then you are potentially part of the problem" suggests a solution. As stated in the summary of this document "The condition of large scale complex ecosystems is commonly influenced by the decisions and actions of many people - often unknowingly. Recognition of this reality is the first stage toward managing on an ecosystem scale."

♦ *Cumulative ecological change* is the consequence of many accumulated and compounded changes, most of which are often very small. It is change by a "thousand cuts" on an ecosystem scale. To warrant managing the many causes, the potential for cumulative ecological change/s must first be evident and the likely significance of causes in their contribution to unwanted effects must be judged. Within an ecosystem, cumulative changes occur incrementally, and can occur in various scales of space and time. Past reliance on *mitigation* to reduce ecological effects to some presumed level of insignificance has almost always left post-mitigation residual effects remaining. When ecological effects of human activities are combined, they interact and can become additive, or less than (antagonistic), or more than additive (synergistic) (Spalding and Smit, 1993). As with any effect, judgement of the significance of a cause/s contributing to an unwanted effect requires a management framework - an idea of what aquatic ecological condition is wanted in the river and/or lake at a given site, and throughout the watershed scale aquatic ecosystem. For example, consider what questions a *manager*, standing on a riverbank, must answer to judge the significance of a proposed addition of a small amount of sediment to a river at a particular site. Then consider what questions this same *manager*, now seated in an aircraft flying high over the watershed, must answer when judging the significance of the proposed addition of many small amounts of sediment to a river at many sites. The role of the *management objectives* in providing the necessary context, and of the ecological knowledge necessary to address these questions, becomes immediately apparent.

♦ *Desired ecosystem condition* is a statement which combines a condition which suits human values, with what is ecologically achievable and ecologically sustainable.

Among individuals, interests and values reflect a wide variety of philosophical (intellectual) and moral (compelling) views - many of which may differ and appear to conflict. Dominant views are embodied in social, cultural, economic and legal traditions. Philosophical and moral views often change in response to the experience and related perception of individuals.

Human interests and values colour and bias the way an ecosystem is perceived (i.e. We don't see things as they are. We see things as we are. - Anaïs Nin -). Consider, for example, how the first European settlers in North America narrowly perceived the substance of ecosystems as only human resources for the taking - and how this view has evolved to present day concern of whether the ecological consequences of proposed human activities are wanted. To afford a clearer understanding of an ecosystem, the effect of this bias should be recognised early, and avoided using an ecocentric perspective. An ecocentric perspective complements an ecosystem approach by focussing the objectives on the contribution of ecosystem structures and on functional processes to the desired condition of the ecosystem, rather than primarily on their commodity (instrumental) value to the human species. Because an ecosystem has many structures and functional processes, and because present knowledge may be imperfect, initial ecocentric discussions should be of the connections between existing or proposed human activities - and the ecosystem structures and functional processes which may be, or have been, affected. This will help establish agreeable intellectual boundaries useful in future discussions, as well as a preliminary list of candidate structures and functional processes of interest. Obviously, the

scientific limitations in making these connections and in predicting scenario outcomes should also be understood.

After candidate ecosystem structures and processes have been identified, relative value is ascertained and affirmed and *valued ecosystem components* are determined. Normative discussions of uses, values and interests dominate this latter process. As the formulation of *management objectives* is a collaborative process, and because ecosystems ecologically differ - management needs will vary among them - there is no single prescriptive formula. It is therefore inappropriate to assume that *valued ecosystem components* will be the same everywhere.

♦ *Ecosystem*: The word "ecology" has Greek roots = oikos meaning "house" and logos meaning "discourse". Like the word "ecology", the word "ecosystem" (coined in 1935 by Tansley) is a sort of metaphor. It refers to "house" and to "system" - with "system" referring "to a method of organization" - suggesting structure, functions, processes, connections and dynamics.

An "ecosystem" is both a concept and a tangible reality (see *ecosystem boundaries*). Tansley (1935) defined an ecosystem as:

> "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the nonliving environment within its boundary"

♦ *Ecosystem approach to management*: see Appendix 3 for a complete explanation; also see the related concepts of *holism* and *reductionism*.

♦ *Ecosystem boundaries* occur at many scales (e.g. a lake, in-stream, or a watershed) and can be affected by influences such as time (e.g. temporary (ephemeral) streams) or by catastrophic events (e.g. geologic events). Boundaries of one ecosystem often overlap with boundaries of other ecosystems. For example, watershed scale aquatic ecosystem boundaries are three dimensional (Likens, 1984) and delineate the above and below ground (i.e. surface and ground water drainage) limits of water flowing through an aquatic ecosystem and include the "washed" portions of terrestrial ecosystems.

♦ *Ecosystem management* (e.g Montgomery, Grant, and Sullivan (1995*)):* taken literally, this is an unfortunate phrase because it inaccurately suggests that ecosystems can be managed (see Appendix 3, and Table A2 - 1; also see *environment* and *management* for more discussion of this). The phrase appears to have originated in U.S. law and has achieved popularity in some disciplinary literature (e.g. Forestry, Planning).

♦ *Enhancement* is undertaken to achieve a previously unrealised condition (e.g. building fish spawning areas where none had previously existed).

♦ *Environment* is not synonymous with "ecosystem". In fact, the word "environment" tends to produce a more narrow view because it forces the user to externalise the environment and set themselves apart - rather than view themselves and other organisms as living within, and co-

dependent on an ecosystem (Great Lakes Advisory Research Board, 1978). The word "environmental" tends to limit a user's perspective by emphasising only the physical and chemical aspects of an ecosystem. The point to remember is that this limited perspective - an artifact of the word "environment" - creates unnecessary intellectual hurdles for the *transdisciplinary* integration so vital in an *ecosystem approach to management*.

"Environment" can be defined many ways. Dictionary definitions include "conditions or circumstances of living", and more life-centred (biocentrically) "external conditions affecting the growth of plants and animals", and human-centred (homocentrically) "physical surroundings and conditions especially as affecting peoples lives".

There are also more prescriptive legal definitions of the word "environment"; for example:

A) **Environmental Assessment Act** RSO 1990

"environment" means,
(a) air, land or water,
(b) plant and animal life, including man,
(c) the social, economic and cultural conditions that influence the life of man or a community,
(d) any building, structure, machine or other device or thing made by man,
(e) any solid, liquid, gas, odour, heat, sound, vibration or radiation resulting directly or indirectly from the activities of man, or
(f) any part or combination of the foregoing and the interrelationships between any two or more of them, in or of Ontario;

B) **Environmental Protection Act** RSO 1990

"natural environment" means the air, land and water, or any combination or part thereof, of the Province of Ontario;

C) **Ontario Water Resources Act** RSO 1990

"natural environment" has the same meaning as in the Environmental Protection Act.

D) **Pesticides Act** RSO 1990

"environment" means the natural environment, a building, structure, machine and vehicle, or any of them;

"natural environment" means the air, land and water, or any combination or part thereof, of the Province of Ontario;

♦ *Goal*; see *vision* and *management objective.*

♦ *Holism and reductionism* are two concepts which are complimentary. Conceptualisation of how the whole system functions is termed "holism". It is generally found "in the eye" of an ecosystem ecologist or perhaps a very experienced naturalist. Applied to an ecosystem, holism requires perception and understanding at a large scale. At it's core, holism holds that the whole of a system is greater than the sum of it's parts - because the parts are interconnected and contribute to the broader functional processes of the whole. Holism is therefore more than just a synthesis of parts applied to complete systems.

Holism seeks to understand the significance of any part or function by relating it the whole. This requires a different plane and scale of perspective. It recognises that ecosystems are more than elaborate clockwork mechanisms with unchanging parts and functions well-suited to reductionist analysis. The system's parts are known to be dynamically and multiply interactive. These dynamics are often non-additive (i.e. more than additive = *synergistic* and less than additive = *antagonistic*) and are often spatially and/or temporally variable. Because an entire ecosystem cannot be "measured", holistic perception relies on ecological intuition and on abstract thought. In some respects, it is an ideal to be striven for.

Reductionism is analysis through simplification by dismantling or dissection. The aim is to discover component parts (structure) and to analyze their individual function. It is a skill generally found in the eye of a microscopist. It is complimentary to holism because it can cumulatively enhance holistic understanding. Reductionists seek to use their understanding to build models intended to accurately mimic the behaviour of systems. Inaccurate mimicry is usually ascribed to insufficient reductionist knowledge. When faced with great complexity, the pursuit of accuracy often results in a long term thirst for knowledge.

Not all the structures and functional processes of an ecosystem are known or fully understood to the point where very accurate modelled mimicry is possible. In addition, it is not possible to "measure" all aspects of an ecosystem. This reality severely limits reductionist efforts to accurately model the dynamics, depth and breadth of an ecosystem's complexity.

For example, a reductionist view of a river is that it is composed of water in a mainstream, tributaries, ground water, lakes, ponds, wetlands, and also contains life. A holistic view of a river emphasises the functional interconnections between all components of the aquatic ecosystem.

Writing holistic objectives is challenging for a number of reasons - including:

- thinking tends to be reductionistic; an artifact of the scientific method. Scientifically and culturally (western) we tend to seek understanding, or to manage and deal with complexity, by viewing something as an assembly of parts - a reductionist approach.
- language creates limitations; an ecosystem is a holistic abstraction while the language we use to describe it is reductionistic
- holism emphasises connectivity; not all ecosystem connections may be known. *Management objectives* are fragments of an interlocking ecological puzzle. It is important to ensure ecological connectivity and completeness so a mosaic is formed depicting the desired condition of a particular ecosystem.

! uni or multi-disciplinary approaches tend to constrain the scope and depth of perception; blending the perspectives of many disciplines is challenging (i.e. being *transdisciplinary*).

Much of the challenge of managing human activities within ecosystems lies in both personal perception and in professional (disciplinary) understanding of ecosystems.

Due to the intra and interconnected nature of ecosystem components, decisions predicted to affect parts of an ecosystem may also ultimately affect some other connected aspects of that ecosystem. If the process of formulating management objectives has been thorough, unwanted effects are those which may affect the relative success of achieving any of the *management objectives* for a particular ecosystem. To prevent these unwanted effects, holistic assessment of a proposed human activity must ensure that effects on all co-dependant management objectives are considered.

♦ In common use, the term *management* can convey many meanings and pre-conceptions - for example consider the eleven "schools" of management described by Koontz, O'Donnel and Weihrich (1980) who also point out that the semantics encountered among these schools often fall from the perspectives of specialists with disciplinarily or organisationally narrowed viewpoints. Consider, for example the related and recent appearance of the phrase "environmental resources" which seeks to bridge two otherwise traditionally narrowed management viewpoints. The common thread among the eleven schools of management is that "management" refers to achieving a purpose or to simply accomplishing certain things. In this document, "management" refers to the decisions and actions taken to achieve objectives. It is recognised that these decisions and actions incorporate such related elements and activities as planning, organising, staffing, leading, commanding, coordinating, and controlling. The reader is referred to Koontz, O'Donnel and Weihrich (1980) for an in-depth discussion of management theory and operational practice. Also see *adaptive management*.

♦ *Management objectives* are initially derived from *vision* or *goal* statements. Management objectives are formulated by persons having an interest in the condition of a particular ecosystem. As human activities are often the cause of undesired changes to ecosystems, knowledge of the expected consequences is used to screen and judge the suitability of human activities.

Each management objective statement should be identically structured. A *management objective* is an explicit quantitative statement which describes the desired state of a particular *valued ecosystem component*. Each objective should also contain a desired target (also see *target*) for the *valued ecosystem component* and a deadline for success. If ecological understanding is insufficient to assign a target, a temporary qualitative direction (a vector of change such as "decrease" or "increase") should be assigned until a target can be established. Each management objective statement should satisfy the strategic directions, ideals and assessment criteria listed in Table 1 and discussed in Appendices 4 and 5.

Formulating objectives is the most difficult step in the hierarchy leading to management because it pre-supposes detailed knowledge of what tasks will be required to achieve objectives since all

objectives should be achievable. Developing management objectives requires knowledge of the purpose to which each will be applied, science and technology, values and interests, and governance. Objectives describe a desired and achievable ecosystem condition. Because objectives describe an ecosystem, objectives are often inter and/or intra dependent - success in achieving one objective may require prior success in achieving other objectives.

"Objective" should not be confused with "task"; the latter properly referring to "how to do something". Also see *vision or a goal* and *regulatory objectives, standards and targets* and *targets*.

♦ *Manager*, in the broadest sense, refers to anyone whose daily decisions and actions have an effect on whether *management objectives* are achieved.

♦ *Mitigation* means "to reduce". It should not be confused with "eliminate". Mitigation of environmental effects leaves residual effects which may persist and, when combined with other residual effects, become *cumulative*.

♦ Regulatory *objectives, and standards and targets* are numerical statements which specify a desired condition of a valued ecosystem component (e.g. a chemical concentration in water). Traditionally, a *standard* is a legally enforceable condition while regulatory *objectives* (e.g. Provincial Water Quality Objectives - "quality" pertaining to a use) and *targets* are not legally enforceable (unless specified as a permit condition required to be met). (also see *management objectives* and *targets*)

♦ *Protection/maintenance/prevention* is undertaken to protect and maintain the existing desired ecosystem condition thereby preventing unwanted change.

♦ *Reductionism* - see *holism*

♦ The intent of *restoration* is to completely return an ecosystem to the predisturbance condition. Success is rarely possible for a variety of ecological and practical reasons (Bradshaw, 1993). Though ecosystem ecologists recognize that ecosystem restoration is rarely possible, the word persists in the literature (e.g. Environmental Protection Agency, 1995) apparently largely due to the quandary created by its inclusion in the 1980 American law - Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Bromley, 1995).

♦ *Rehabilitation* is undertaken to return an ecosystem to a close approximation of its condition prior to disturbance. The results fall short of complete restoration (see Bradshaw (1993) and *restoration* above).

♦ *Targets*: an endpoint, vector or.....? Targets contained in objectives describe what measurable condition is desired. Targets describe limits of quantity or quality. Establishing targets requires prior knowledge of what is valued and of ecology.

As previously mentioned, it is not possible to manage an ecosystem, only human activities can be managed. The purpose of a target is to guide related management decision-making and to ensure that success in achieving an objective is verifiable. Targets should not, however, be viewed as static endpoints because an ecosystem is dynamic. To be ecologically realistic, targets should incorporate elements of events affected by chance (*stochasticity*). This will ensure that targets are sufficiently flexible to allow for the more common natural fluctuations in ecosystem conditions (e.g. think of weather forecast - such as an 80% chance of rain ... or as statistical confidence limits...etc). It is recognised that such targets will likely not accommodate the occurrence of unpredictable events (*chaotic conditions*), particularly those which are extreme. For example, a community of aquatic larval insects living in a loosely consolidated rubble bed of a hilly headwater stream may suddenly be swept away by an unpredicted violent flood resulting from an extreme rainfall event - this is chaos in action.

When allowing for natural variability, remember that there is a tendency to think of averages (e.g. the average density of aquatic invertebrates per square metre) as the signal, and variability (e.g. in density of aquatic invertebrates between square metres) as extraneous noise. The reality may be that the variability is the signal and the average is the noise. Variability may increase or decrease around an average - the value of the average itself may be misleading. In some instances, knowledge of what is ecologically achievable may be too imperfect or inexact to establish targets based on probability (i.e. stochastic targets). In such cases, temporary targets should be established to provide a directional heading (a *vector*) so that subsequent management actions are generally aimed toward the desired condition of the ecosystem. Scientific professional judgement should be used to help ensure that temporary targets or directions are ecologically compatible with achieving other objectives.

Since vector headings are not firm (e.g. percent reduction in a particular pollutant), specificity should be continually improved until a vector becomes a target and the criteria contained in Table 2 are satisfied. Iteration should use adaptive management techniques employing trial, monitoring and feedback. (also see *objectives, standards and targets*)

♦ The word *transdisciplinary* was coined to describe a way of combining knowledge and understanding within a management framework (Saha and Barrow, 1981; Dorcey, 1991(b)). It is based on the realization that there can be great perceptive and cognitive bias associated with more traditional ways of obtaining and combining knowledge and understanding. This bias can subvert both the design and implementation of an *ecosystem approach to management*.

"Unidisciplinary" means a perspective dominated by the doctrines of a single discipline - it is also reductionistic within the doctrine of that discipline; "multidisciplinary" means an attempt to combine the final inferences and recommendations of a number of uni-disciplinary views representing many disciplines - and then trying to resolve conflicts and shortfalls which later become apparent; “interdisciplinary” means sharing between or among disciplines; "transdisciplinary" means across or through disciplines - to have a fully integrated view formed throughout the preparation, study design, research, and conclusion/ recommendation phases of work with no "forcing" of the results at the end. Transdisciplinary work can only result from the

efforts of cross-trained persons who integrate their efforts by both sharing and inter-relating their disciplinary doctrines, and by co-developing final inferences and recommendations.

The purposeful and intentional blurring of disciplinary boundaries needed to be *transdisciplinary* must extend to the management theory on which it is based. As pointed out by Koontz, O'Donnell and Weihrich (1980), the present situation is that the opposite tends to prevail - a "management theory jungle" exists because of a lack of transdisciplinarity. They concluded that "...[management] approaches tend to vary in their semantics and their view of management, and approached the theory of management from different specialists' point of view." The *transdisciplinary* basis of an ecosystem approach to management anticipates and prevents this traditional clash of perspectives.

Training in transdisciplinarity does exist. Because it takes from many different disciplines, ecosystem ecology is perhaps the most transdisciplinary science.

♦ *Valuation* refers to the act of valuing. Value is a concept which can be gauged many different ways - not just monetarily.

♦ *Valued ecosystem components (VECs)* (Beanlands and Duinker, 1983) are the ecosystem structure/s and functional process/es on which value is placed. VECs are the backbone of each *management objective*. Each VEC, or an ecologically related surrogate, is named in an objective statement. It then becomes the object of management decisions and activities (e.g. protecting a favoured but threatened foodstuff such as cisco; a prey species, and a potential surrogate of a valued organism such as lake trout). The selection and valuation of VECs, and their use and translation into *management objectives*, is both an art and a science. It blends perception of an ecosystem and ecological understanding with a value system expressed as attitudes.

Most people will agree that we will tend to protect what is considered valuable and ignore what is not. History has taught western society that the many interconnections and co-dependancies within a watershed-scale ecosystem must be considered to prevent problems which may otherwise result when we try to “ignore what is not” (see explanation of an ecosystem approach in Appendix 3). Emphasising the valued components of an ecosystem makes it impossible to forget the interconnections and dependancies within an ecosystem - including sustaining human dependancies and uses.

What value system should be used to select ecosystem components? What components of the ecosystem are held to be important? Are changes to ecosystem components only important if they directly effect humans? Should we reach beyond self-interest? These are among the many questions which should be asked when deciding what VECs should be selected. A philosophical difficulty in answering such questions arises from the need to strike a balance between the world "...as it is..." (including humans) and the world "...as we are...". Though partners will rarely completely agree on a common value system, it is important to always keep in mind the effect of value systems held by partners on what can be achieved in planning on an ecosystem scale. Underlying values are particularly important in principled negotiation.

♦ *Vector* - see *management objective* and *targets*.

♦ A *vision or a goal* are synonyms (see NOTE$_1$) for an imagined state. Each is a simply worded broad brush idealized and qualitative view (i.e. a normative standard (Vaske, Donnelly and Shelby, 1993)). Vision or goal statements result from thinking broadly. They assume no constraints to success.

Developing vision or goals is an art, not a science. Visions and goals will not satisfy the five criteria listed in Table 1. Visions or goals may reflect perceptions rather than facts. Visions or goals will reflect human values and are often human-centred (being tied to our desired uses of an ecosystem).

Visions or goals can be used to help identify valued ecosystem components, and to help determine strategic management directions needed (i.e. see Table 1). As visions or goals provide only a general unmeasurable description they require translation into measurable statements.

NOTE$_1$: In this work, *vision* is considered to be synonymous with *goal*. It is recognised that this definition is contrary to the meaning described by Koontz, O'Donnel and Weihrich (1980) - who view "goal" to be synonymous with "objective", and also contrary to many dictionary definitions. However, as also pointed out by Koontz, O'Donnel and Weihrich (1980), "...clear distinctions tend not to be made uniformly by writers and practitioners..." and so a convention must be adopted. As many Ontario "corporate cultures" consider *vision* and *goal* to be synonyms, this convention was adopted herein.

APPENDIX 2

IMPORTANCE AND SOME USES OF MANAGEMENT OBJECTIVES IN DECISION-MAKING

Importance of Management Objectives

Management begins with a description of the end in mind. *Management objectives* bestow responsibility for preventing unwanted ecological change on people, groups or agencies who otherwise may unknowingly cause it. As all planning and implementation measures flow from the need to achieve the *management objectives*, formulating these objectives is therefore the single most important step in the process leading to *management* (Schueler and Long, 1970; Barber and Taylor, 1990; Kershner, Forsgren and Meehan, 1991; Deyle, 1995; Slocombe, 1998).

A collaborator's expectations of the clarity and completeness of *management objectives* will be high because of the many immediate and potential uses of the objectives (e.g. Table A2-1) and the consequences of these uses. Most especially, collaborators expect objectives to unite them in a common purpose by focussing and guiding their individual *management* decisions and subsequent actions (particularly among those with otherwise converging, diverging or overlapping mandates, and with jurisdictional boundaries which meet within ecosystems). They expect that this focus, unity, and reduced overlap will save time, money and effort in later planning and implementation stages. Each collaborator will also expect to be able to assess their own degree of success in achieving *management objectives* so they can judge whether adjustments to *management* decisions or actions are necessary.

The time, effort and care used to formulate unambiguous, detailed and useful *management objectives* will obviously be well invested.

TABLE A2-1 - Some examples of how management objectives can be used in decision-making

SCREENING AID FOR IDENTIFYING HUMAN CAUSES OF UNWANTED EFFECTS: This knowledge provides the basis for management. The significance of predicted or existing ecological/environmental effects is judged according to whether they contribute - or interfere with success in achieving *management objectives*. The predicted outcome clarifies the management decision needed. Collaborators can then prevent unwanted ecological consequences by selecting management and development scenarios and activities most consistent with achieving ecosystem scale *management objectives*. Causes of unwanted effects should be prevented. Using ecosystem scale *management objectives* in this fashion is recognised as the only way of identifying and preventing unwanted *cumulative effects* (Canadian Environmental Assessment Research Council and United States National Research Council, 1986; Canadian Environmental Assessment Research Council, 1988; Sparling and Smit, 1993; Williamson, 1993)). This logical explicit management framework also allows a manager to easily explain, defend or otherwise justify a decision or action.

Preventing perverse unwanted ecological changes in an ecosystem is more efficient and less costly than reacting to, and modifying or rehabilitating unwanted effects once created and avoids risking complete loss. Full restoration or enhancement may not be possible.

FOCUS FOR UNIFYING AND ORCHESTRATING MANAGEMENT DECISIONS AND SUBSEQUENT ACTIONS OF COLLABORATORS: Where the decisions and actions of more than one collaborators are required to achieve management successes, objectives provide the common focus - the "orchestral score" needed to "unify". Collaborators agree on the desired condition of the ecosystem. *Management objectives* depict this desired condition. Each collaborator uses the context provided by the objectives, and particularly the objectives for which they are accountable, to identify and manage activities which may affect success in achieving the *desired ecosystem condition*.

INCREASE ACCOUNTABILITY FOR ACHIEVING MANAGEMENT OBJECTIVES BY THOSE RESPONSIBLE FOR HUMAN ACTIVITIES WHICH MAY AFFECT SUCCESS: Management of the many human activities within an ecosystem which could affect success in achieving *management objectives* cannot occur without co-operation and collaboration of parties responsible for those activities. Individuals, groups, businesses and all levels of jurisdictional governance will be accountable for the ecological consequences of their decisions, actions and activities, or lack thereof.

PROVIDING COLLABORATORS WITH AN OPPORTUNITY TO VERIFY THE SUCCESS OF THEIR INDIVIDUAL AND JOINT EFFORTS: The *management objectives* describe the desired condition of the ecosystem in sufficient detail so that there can be no doubt when success is achieved. The degree of success is verified through monitoring. The monitoring "feedback loop" can be used like a burglar alarm, to alert managers of the need to correct mistakes, and to learn - where knowledge may have been imperfect (*adaptive management*), and - by doing so - help prevent the loss of the values described in the *management objectives*. *Management objectives* provide the focus needed to designers of monitoring programs for selecting relevant indicators of unwanted changes in the condition of an ecosystem.

Regulatory agencies, such as municipalities, can also judge the significance of not achieving a management objective (and thus losing *valued ecosystem components*) when deciding whether abatement or enforcement actions are warranted.

DETERMINING THE RIGOUR AND EXPENSE OF THE SUBSEQUENT SAMPLING DESIGN/S AND OF THE SORT OF DATA ANALYSIS NEEDED: *Management objectives* provide the management context needed for the design of sampling programs (e.g. for reconnaissance, baseline and subsequent monitoring programs) and for the prediction of the ecological future.

DETERMINING THE DESIRED USES OF DATA, AND THE TYPE, QUANTITY AND QUALITY OF ECOLOGICAL DATA NEEDED: A pre-conceived notion of how monitoring results will be used in *management* decision-making is used to refine the content of each objective statements.

APPENDIX 3

UNDERSTANDING AN ECOSYSTEM APPROACH TO MANAGEMENT

1.0 UNDERSTANDING AN ECOSYSTEM APPROACH TO MANAGEMENT

It has long been known that implementing an *ecosystem approach to management* will require careful orchestration of collaborators to fulfil detailed *management objectives* (Great Lakes Research Advisory Council, 1978; Lee, Regier and Rapport, 1982; Canadian Environmental Assessment Research Council and United States National Research Council, 1986; World Commission on Environment and Development, 1987). This realization is based on an understanding of management theory, science, techniques and operational practice.

As explained by Koontz, O'Donnell and Weihrich (1980) in their examination of management theory, science, techniques, and practice of management, the term "approach" simply means a "school of thought". They (and others such as Kerzner, 1989) also describe the long established "systems approach" to management which emphasises the interrelatedness and interaction within and between systems and the need to perceive and understand these. The phrase "ecosystem approach" was first used by the Great Lakes Research Advisory Board (GLRAB) in a 1978 report to the International Joint Commission. It was coined to describe a basic change in the way of looking at things (a fundamental paradigm shift). The paradigm shift was required to recast perception of pollution problems to ensure that functionally related parts of an ecosystem (such as land and water in aquatic ecosystems) were considered in management decisions. The change was toward viewing organisms as living within an ecosystem and dependant on it (e.g. humans-in-an-ecosystem), rather than as external and living apart from it (GLRAB, 1978; Vallentyne, 1987). The effect of this new approach was to undo perceptual constraints and refocus management thinking. The new focus improved the chances of management success at greatly reduced cost by revealing a cascade of management opportunities to prevent unwanted ecological changes. How? Ecological cause and effect linkages within an ecosystem, which had formerly been overlooked by managers, suddenly became visible. The sum total of human activities within a watershed were finally seen to collectively affect the condition of the aquatic ecosystem within (in this instance, within the greater watershed of the Great Lakes). The management response was toward collaboration and co-ordination of multi-agency decisions to achieve common management goals within *ecosystem boundaries* - and the "ecosystem approach" was born.

Since the birth of the concept, much experience with an *ecosystem approach to management* has been gained. Table A3-1 contains a summary of some strategically important concepts associated with this approach.

At the heart of an *ecosystem approach to management* are at least four practical requirements:

1) THE *ECOSYSTEM BOUNDARIES* ARE DEFINED:
These are the management boundaries used in an ecosystem approach.

2) VALUES FIRST; THEN ECOSYSTEM REALITIES: *Management objectives* embody and integrate values with ecosystem realities to describe what is then commonly held to be important. When completed, *management objectives* provide the ecosystem scale socio-ecological-economic context for related decision-making.

Concern over the future of humanity has prompted a global and national consensus that present day human values must rapidly evolve so that the central goal of ecological

TABLE A3-1	**Some strategic concepts associated with an ecosystem approach to management (after: Meadows, Meadows, Randers and Behrens III, 1974; Great Lakes Advisory Board, 1978; van der Maarel, 1978; Likens, 1984; Lee, Regier and Rapport, 1982; Healy and Wallace, 1987; World Commission on Environment and Development, 1987; Vallentyne and Hamilton, 1987; Likens, 1992; Sparling and Smit, 1993)**
!	ecosystems are not closed systems; they overlap with other ecosystems and are connected (e.g. water moving through watershed scale aquatic ecosystems has first scrubbed the air, and then washed the land and structures of terrestrial ecosystems)
!	for management purposes, ecosystems have operationally defined boundaries (space and time dimensions) which allow increased understanding, and the verification of causality (Likens, 1992)
!	ecosystems are complex
!	ecosystems are comprised of structures and functional processes
!	dynamic linkages occur between structures, and functional processes within an ecosystem
!	there are degrees of connectivity of ecosystem structures and functional processes. While "everything may be connected", connections often occur in webs and linkages and are not always close.
!	short and long term variability exists within an ecosystem
!	change within ecosystems is pervasive and often occurs at different scales, speeds and levels of complexity. There is more to ecosystem dynamics than just "big changes". Perception of ecosystem change can be challenging because changes may be small and, either difficult to perceive, or may evade human perception (i.e. ecosystem change by tiny increments).
!	all organisms (including humans) live in an ecosystem, and are dependant on one or more ecosystems
!	there are natural limitations in the capacity of an ecosystem to sustain a use or multiple uses (e.g. the harvest of fish, the breakdown of wastes) which depend on the structure and functioning of the ecosystem
!	there are limits to the extent to which natural limitations may be technologically stretched to sustain a use or multiple uses (e.g. augmentation of soil to extend its fertility)
!	ecosystems cannot be managed; only human activities can be managed
	The condition or state of an ecosystem is the result of responses to manageable human activities and to other natural stimuli which are beyond human control. Ecosystem change is therefore inevitable. We can only manage human activities and interaction within an ecosystem to prevent unwanted ecological consequences of those actions. "Management of an ecosystem" is clearly a feat beyond human ability (Regier, Welcomme, Steedman and Henderson, 1989; Montgomery, 1995). For example, rather than implying "ecosystem management", "watershed management" actually refers to the scale of the ecosystem within which human activities are managed.

sustainability of human activity can be achieved (e.g. World Commission on Environment and Development, 1987; Harmony Foundation of Canada, 1988; Daly and Cobb Jr., 1989). Success in achieving this central goal will require seeking synergy of human activities within an ecosystem (meaning working within natural constraints), rather than employing the more traditional tradeoff or compromise models which tend to incrementally work against success.

An *ecosystem approach to management* is based on a broader sense of value and a related way of looking at natural and cultural processes which differs from more narrow conventional and

dominant traditional perspectives. Use of an ecosystem approach requires a paradigm shift toward ecological phenomena. This new paradigm requires more forethought about underlying values, and general goals for human life and culture, which then colour our view of the desired condition of a particular ecosystem (Healy and Wallace (1987)).

Values and perspective are intertwined. An ecosystem-centred (ecocentric) perspective is needed to employ an ecosystem approach to formulating *management objectives*.

3) ECOLOGICAL KNOWLEDGE AND UNDERSTANDING EXISTS AND IS USED: This knowledge and understanding allows an assessment of ecosystem past and present realities, and permits prediction of the ecological future.

Knowledge and understanding of an ecosystem and how it works (i.e. it's structure and functional processes) provides the scientific foundation and framework of an ecosystem approach (for example, see Murphy and Meehan, 1991). The ability to assess and gauge the condition of an ecosystem is fundamental to an ecosystem approach. Understanding of ecosystem realities ensures that all relevant interconnected elements within an ecosystem will be considered in management decisions. It also provides collaborators with a sense of the availability and limitations of ecological dynamics which are needed to prevent the loss of values desired in an ecosystem.

"SYSTEM THINKING" IS USED: "System thinking" is used to understand an ecosystem and how it works. This is needed to ensure that all relevant interconnected elements within an ecosystem are considered in *management objectives*, and in subsequent management decisions.

Applying "system thinking" to ecosystems requires using both *holism* and *reductionism* - knowing how each are likely to colour understanding. For example, ecosystem complexities in space and time defy complete dismantlement into a heap of parts like a machine. The consequence is that an ecosystem is held to be greater than the sum of its parts (*holism*). This reality at once seems in conflict with the belief and assumption underlying the "scientific method" which holds that complete understanding and certainty can only be achieved through simplification of complexity (*reductionism*). The obvious assumption is that complexity can be dismantled like a machine (it is *mechanistic*). The basis for understanding of an ecosystem is instead probabilistic - meaning that complete understanding in a way which guarantees certainty is unlikely. This reality may cause some intellectual discomfort among very conservative collaborators who would prefer to see the world in a mechanistic way. However, remember that most people willingly use weather forecasts - though they are stated in probabilities - and are therefore inexact. Similarly, economic forecasting is also an inexact, but much used process.

CAUSALITY IS SUFFICIENTLY UNDERSTOOD: The root cause or causes, process/es or mechanisms of ecosystem change, the result/s of the effect, and the time (temporal) and spatial dimensions should be understood sufficiently to provide collaborators with the basis for predicting the ecological future. Long and short term consequences of human activity should be considered.

For example, forest clearing causes ecological changes which include hydrological modifications, soil loss, soil compaction, changes in instream chemistry and hydraulics, aquatic habitat changes and a host of other related consequences.

PERCEPTUAL AND COGNITIVE BIASES ARE RECOGNISED: There are important management implications of not recognising the presence of these biases (e.g. biases founded on ways of knowing (disciplinary biases), and biases founded on underlying values).

Understanding ecological realities requires recognising the important implications of perceptual bias (often values related) and related cognitive bias. For example, conceptually limiting or sometimes vague and confusing metaphors or allegories such as;

- the "ecosystem as an organism" (Clements and Shelford, 1939),
- the related "Gaia hypothesis" (Lovelock, 1979) and other ecosystem "health" and "behaviour" metaphors (Rapport, Regier, and Hutchinson, 1985; Rapport, 1989),
- ecosystem or ecological "integrity" from USA-EPA 1972 Federal Water Pollution Control Act legislation (United States Environmental Protection Agency, 1975) and subsequently discussed by many other authors including Cairns, (1977), Karr and Dudley (1981), Regier and France (1990), Karr (1991), Karr (1993); and
- ecosystem "stability" (Brookhaven National Laboratory, 1969 - a metaphor borrowed from discussions of Community Ecology theory),

have recently been used to quickly describe complex ecological concepts to lay audiences (Rapoport, 1983; Steedman, 1994) - but for a particular purpose. As pointed out by Regier, Welcomme, Steedman and Henderson (1989), "...the problem is not how to gain acceptance of an ecosystem approach - that process is already underway. The problem is how to foster further development of a paradigm consistent with an ecosystem approach....". Though promoting conceptual bias, these popular metaphors and allegories have been effectively used to simplify ecological concepts in a way intended to further discussions among management decision makers of the underlying values behind decisions. However, it is very important that lay collaborators not mistake the very simplified and biased understanding derived from these metaphors and allegories for mainstream scientific doctrine.

While formulating *management objectives*, it will be useful to remember an old adage which describes both the source of, and general relationship between, most perceptual and cognitive bias:

> "Where we stand depends on where we sit. We see the world, not as it is, but as we are: our perception is coloured by our experience."

We should be open to shifting between paradigms if we wish to eliminate perceptual and cognitive biases in the search for reality (Barker, 1993).

4) *TRANSDISCIPLINARY* INTEGRATION OF KNOWLEDGE AND UNDERSTANDING: Fully integrated management can only be achieved using

transdisciplinary understanding and skills.

The ability to integrate is tied to an ability to recognize and eliminate perceptual and cognitive biases described in (3). Translation of an ecosystem approach into tactical delivery requires *transdisciplinary* skills - an ability to shift and blend perspectives among disciplines. This ability is invaluable when considering the interrelationships between *management objectives*, and in evaluating the achievability of objectives.

Also see the explanations of concepts and terms in Appendix 1 - especially of *cumulative ecological change*, *ecosystem*, and *environment*.

APPENDIX 4

EXPLANATION OF THE IDEALS AND STRATEGIC DIRECTIONS OF MANAGEMENT

Ideals of *management*

Effectiveness, efficiency and fairness are general ideals which *management* strives to achieve. Innovation is often required to achieve all three.

Effective *management* is objective-oriented. Objectives should be explicit and achievable. Success in achieving objectives should be verifiable.

Efficient *management* achieves objectives in a thrifty and timely fashion. Co-dependencies among objectives are made obvious by grouping them.

Fairness requires even-handedness with no favouritism. It requires consensus by collaborators on the values underlying the process, on the objectives to be achieved, and a clear and unbiased understanding of roles and accountability.

Strategic directions of *management*

There are three strategic directions of *management* activities:

(1) maintenance through protection and prevention

Maintenance of existing *desired ecosystem conditions* is achieved through protection of desired ecosystem structures and functional processes by managing the human cause(s) of unwanted ecological changes. Human causes of unwanted effects are identified by assessing whether the ecological consequences of all decisions and human activities either contribute to, or detract from continued success in achieving the *management objectives*.
It should also be noted that reducing ecological effects through *mitigation* is not equivalent to preventing the cause.

(2) rehabilitation

Rehabilitation seeks to return changed ecosystem structures or functional processes to a close approximation of their condition prior to disturbance. This strategy is used where the opportunity to prevent harm has either been missed by decision-makers, or has failed. It is important to remember that complete *restoration* is rarely possible; unwanted changes may be permanent (Bradshaw, 1996).

(3) enhancement

Enhancement is undertaken to achieve a previously unrealised ecosystem condition (relative to the pre-human habitation condition). Enhancement is usually directed at improving a particular use (often a human use). For example, enhancement of a kayak slalom course on a river may be undertaken by the manipulating flow regime and the location of boulders. A fishery might be

enhanced by enhancing fish habitat - constructing spawning and rearing areas where none had previously existed.

Which Strategic Direction of *Management* is Preferred?

Anticipating, and then modifying or eliminating causes of unwanted effects will significantly reduce the inefficient and costly need to react to unwanted effects. Rehabilitation of ecosystems is difficult and can be costly, or may not be ecologically possible to the point desired. Maintenance is therefore the strategy of first choice, followed by rehabilitation and then enhancement.

APPENDIX 5

EXPLANATION OF ASSESSMENT CRITERIA

1.1 Assessment Criteria for Draft Management Objectives
1.2 Criterion 1: Clearly worded
1.3 Criterion 2: Achievable
- Ecologically and Scientifically
- Collaboratively
- Fiscally

1.4 Criterion 3: Verifiable
- Linking management objectives, monitoring, assessment of progress and success, and management responses

1.5 Criterion 4: Ecologically Complete
1.6 Criterion 5: Accountable for Success

1.1 Assessment Criteria for Draft Management Objectives

The five assessment criteria listed in Table 1 of the text are explained in this Appendix. In addition to the ideals and strategic directions of management, these criteria are used to assess whether the ten-step process of formulating *management objectives* is complete.

It is assumed that readers of this Section fully understand the context for their use as explained in Section 3 of this document.

Management objectives should be clearly worded, achievable, verifiable, ecologically complete, and there should be accountability for success. Satisfying these criteria should be evaluated over appropriate time frames - particularly to ensure achieving the concomitant aim of achieving sustainability of human activities through ecological synergy.

Why should a management objective be clearly worded, achievable, verifiable, ecologically complete, and why should there be accountability for success? There are many reasons - some are practical and tactical project management reasons (e.g. Kerzner, 1989), others are more strategic with a general purpose in mind (e.g. uses described in Appendix 2), and all have to do with the success of management of human activities within a particular ecosystem. All reasons have to do with "putting the wheels on the pavement".

To the advantage of each accountable collaborator, an achievable, verifiable and ecologically complete objective is of immediate practical use in a "management framework" - a structured linkage of purpose and knowledge with management decisions and actions (e.g. Kerzner, 1989; Somers, Mierle and Yan, 1994). The management "framework" closely links *management objectives*, and monitoring, and assessment of progress and success directly with the collaborators accountable for success. The collaborator then uses this feedback in a very practical way to stay on the road to success by fine tuning management decisions and actions where needed.

1.2 CRITERION 1: Clearly Worded

It is a generally accepted principle that clear wording usually reflects clear thinking. The vocabulary of objectives should be understandable by all collaborators, decision-makers and users. It should be both clear and precise (Burkardt, Lamb, Taylor and Waddle, 1995).

Clearly-worded *management objectives* should contain details stated in a way which dispels any confusion about intent, or the decisions and/or actions needed. For example, an objective should refer to a *valued ecosystem component*. It should identify "what" and "how much" is to be done; not "how" to do it (a task). A subsequent plan should list and describe tasks.

Though an objective should not describe tasks, prior working knowledge and insights of "how to" (i.e. tactical knowledge) is needed to help word objectives in a way which will prevent future misinterpretation. Tactical knowledge and experience of "how to" should greatly influence the

wording and content of an objective. This should include prior knowledge of appropriate scientific design (e.g. in support of *adaptive management*, monitoring,...etc), what tasks must be connected to an objective, task implementation sequence and timing, the logistical arrangements necessary (e.g. how to circumvent limitations imposed by the degree of collaborative arrangements), and how to influence human behaviour in the particular ecosystem (e.g. by using or adapting or writing guidelines, codes of environmental practice, policies, economic incentives or by using *command-and-control* instruments such as regulations or bylaws,...etc).

Checklist for CRITERION 1: Clearly Worded	
"	understandable by all collaborators, decision-makers and users
"	dispels any confusion about intent
"	precise
"	each *management objective* refers to a valued ecosystem component
"	based on sound tactical knowledge of "how to"
"	defines "what" and "how much"; not "how to"
"	does not require further interpretation by users

1.3 CRITERION 2: Achievable

"Achievable" means that the desired result(s) is (are) actually attainable. Achievable *management objectives* are intended to provide the "blueprint" for future implementation.

Management objectives should be ecologically and scientifically, collaboratively, and fiscally achievable.

A practical assessment - a "reality check" - should be used to judge achievability of what is proposed in a management objective. The achievability of all tasks needed to accomplish each management objective should be assessed. This will require excellent understanding, special skills and prior "hands-on" experience.

The reality check should be forward-looking. Assess the achievability of *management objectives* over the short and long term.

Assess whether full use is being made of the capabilities available or possible (e.g. human, fiscal, technical, scientific). If an objective is judged collaboratively or fiscally unachievable, consider alternatives to complete rejection, particularly if the success of other objectives is ecologically linked and therefore co-dependent. Some options include revision, deferral, or improved innovation.

Ecologically and scientifically achievable

Ecological and scientific achievability are two sides of the same coin. "Ecologically achievable"

simply means that the ecosystem "agrees" with the management expectation and the outcome will be ecologically sustainable for the desired duration. For example, though an enhancement objective may be that Brook Trout actually use an artificial spawning area, existing physical or chemical characteristics of the water may preclude success. "Scientifically achievable" means that there is enough understanding of causality to predict the ecological future with the accuracy and precision needed to assess a management expectation.

If a management objective is not ecologically achievable, it cannot be done. If the desired result is not ecologically sustainable, the wisdom of proposing the management objective should be assessed further. If it is not scientifically achievable, more understanding of causality is needed.

Collaboratively achievable

"Collaboratively achievable" means that the right people have been recruited to collaborate in achieving each management objective. Collaborators should be selected based on the knowledge, skills, abilities, and talents needed to achieve each management objective. Judging this criterion will require specialised knowledge of what knowledge, skill, abilities and human resources will be needed to achieve each management objective. Insufficient and/or inappropriate collaborators can jeopardize achieving objectives.

Being collaboratively achievable is especially important when *management objectives* are ecologically co-dependant on one another - where success in achieving an objective has a bearing on success in achieving one or more ecologically linked objectives.

This can seem like a "chicken and egg" problem; which comes first - collaborators or *management objectives*? Determining who is needed to collaborate is usually an iterative process. The process of translating *vision* or *goal* statements into *management objectives* should help to determine collaborators most needed. As this translation proceeds, the need for new, or ecologically linked objectives - and yet more collaborators - may also become apparent.

One of the greatest challenges of managing on an ecosystem scale arises when attempting to manage many existing diffuse causes of unwanted ecological change (e.g. human sources/causes). It may be very difficult to word an objective so that a single collaborator can be fully accountable for achieving a particular management objective. Assessing collaborative achievability requires practical understanding of how collaborations are formed, of their dynamics and of how they may be orchestrated. Many manuals and books outlining methods and techniques for consulting with groups of people and facilitating self-managing collaborative teams are readily available (e.g. Hicks and Bone, 1990; Quick, 1992; Ontario Ministry of Environment and Energy, 1994). Bolling (1994) provides insights in how to create an atmosphere which invites and involves public participation to enable widespread collaboration among the public.

Table 3 in Section 3.2 provides some additional criteria useful in screening prospective collaborators with varying capabilities. Collaborators will need particular knowledge, skills, and

talents (e.g. scientific, technical, leadership, communication, facilitation, diplomatic, education, political liaison, public policy...etc) to formulate *management objectives*.

Fiscally achievable

"Fiscally achievable" means affordable over the short and long term. Though *management objectives* do not state tasks, the affordability of the tasks required to achieve each objective must be considered (particularly for objectives in the more costly rehabilitation or enhancement categories).

Management objectives are an expression of what is valued (see *valued ecosystem components*). Fiscal achievability is only one of a number of perspectives used in deriving them. It is very important to remember that the way in which an issue is perceived may be causing a "problem"; the benefits of shifting the dominant mental paradigm should not be ignored (Barker, 1993). For example, when assessing fiscal achievability, it is important to consider how the cost of implementation may vary with factors such as:

- the cost of maintenance/protection versus the cost of later rehabilitation or enhancement - if opportunities for maintenance are missed (for example, compare the cost of alternatives using "full-cost accounting" or ecological economics.

- the cost of forever not achieving a management objective - where an objective may be ecologically and collaboratively achievable, but may be judged not fiscally achievable

- comparing different ways of measuring value with a single method - fiscal valuation

- cost of tasks arising from a management objective (e.g. some tasks may be more easily executed because they are based on existing guidelines, codes of environmental practice, policies, regulations, command and control mechanisms, others may need invention of new guidance...etc)

- the complexity and scale of the tasks required to achieve a management objective (for example the sociological complexity, or situations where achieving success in one management objective is ecologically dependant on achieving success in other objectives - especially in rehabilitation and enhancement categories).

The fact that present day fiscal limitations on achievability can change with time should lead to optimism. Judgement of fiscal achievability should therefore be viewed in more than just the fiscal context of the day. Options other than outright rejection may exist for a draft management objective which otherwise satisfies all other criteria, but which is judged to be fiscally unachievable. For example, one option is continued pursuit through existing collaborators of the means to make the objective achievable. Another option involves increased innovation. For example, revisit the proposed management objective and determine if it can be reduced into more

fiscally achievable portions. Another is to locate or create new funding sources. Another option may be to increase the availability of volunteer effort by increasing collaborative arrangements with community groups. Other options may be discovered by "brainstorming" the problem with all collaborators, or by networking with other groups who have already formulated *management objectives*.

Checklist for CRITERION 2: Achievable

- " desired ends can be actually attained
- " provide the detail needed for future planning and implementation
- " ecologically and scientifically achievable
  - the ecosystem "agrees" with the management expectation
  - there is enough understanding of causality to allow prediction of the ecological future with sufficient accuracy and precision for formulating the *management objectives* needed
- " if a management objective is judged "ecologically unachievable" it cannot be done and should not be attempted. If the desired result is judged "not sustainable", the wisdom of the management objective should be reassessed.
- " collaboratively achievable
  - there is an appropriate collaborator for each management objective
- " fiscally achievable
  - affordable over the short and long term

1.4 CRITERION 3: Verifiable

"Verifiable" means that the progress toward, and the relative success in achieving a management objective can be measured and assessed - and acted on if necessary in fulfilment of management on an ecosystem scale. A management objective should be stated in a practical way which links it to a relevant and achievable preconceived monitoring design.

Linking management objectives, monitoring, assessment of progress and success, and management responses

The content and detail of a management objective should be linked and tailored so a particular collaborator can detect and measure the type and degree of change in an indicator, and initiate a particular "course correcting" management response if needed. This linkage allows the use of *adaptive management*. This linking and tailoring should be done when the *management objectives* are being formulated to avoid possible later misinterpretation of intent.

For each objective, it is necessary to determine the range and type of management responses possible, and the sort and degree of ecological change needed to trigger the response(s). A management response should be initiated when an unwanted type or amount of change is detected, or when an unacceptable condition, situation or unmet deadline for achieving a management objective is encountered. If no management response to unwanted change is possible, less rigour

may be paid to the structure and wording of the management objective and no monitoring program may be needed. The resulting objective may no longer have a management function, and may fail to satisfy the "verifiable" criterion.

A verifiable objective should focus primarily on desired ecological results. The statement requires specific structure. Each objective should:

- **!** contain a measurable indicator. An indicator may be either a biophysical component (e.g. an ecosystem structure) or a ecosystem functional process. The indicator selected often echoes the values held. An indicator may, of itself, not be directly valued. In such instances, it may be a convenient surrogate for something which is valued.

- **!** describe a target condition desired (e.g. description of what would constitute maintenance, or rehabilitation or enhancement)

- **!** contain a completion date - particularly where success of *management objectives* are inter/intradependant.

It is necessary to consider how, and under what circumstances indicators and *targets* will be used to trigger a "course correction" management response.

Judging the relevancy of indicators, and of the trigger/s to be used requires many perspectives, practical, and specialised knowledge. For example, knowledge should include what *target* ecological condition is desired, causality, the characteristics of an ecologically suitable indicator of unwanted change, what candidate indicators exist in the ecosystem, which potential indicators are already directly valued (e.g. a particular species of fish) by collaborators and decision makers, what management responses to unwanted change are possible, what indicators and triggers are appropriate for each management response, design options for monitoring, evaluation and assessment procedures options for data,.....etc.

Checklist for CRITERION 3: Verifiable

- **"** progress toward, and the relative success in achieving a management objective can be measured and assessed
  - focus primarily on results
  - contain a target, relevant indicator and completion date
  - linked to a pre-conceived monitoring design and data analysis designed to detect and measure the type and degree of change felt unwanted and to assess progress toward success
- **"** well-defined management responses in mind
  - content and detail of a management objective is linked to a preconceived management response

1.5 CRITERION 4: Ecologically Complete

"Ecologically complete" means that, within an ecosystem, all dependencies which could affecting success in achieving a particular management objective have been considered. Judging this criterion requires specialised ecological knowledge (e.g. excellent knowledge of causality) and *transdisciplinarity*. Satisfying this criterion is at the heart of an *ecosystem approach to management*.

Consider ecologically linked groups of *management objectives* which are ecologically interrelated and co-dependant and make them known by cross-referencing these connections. Dependencies can occur both spatially and in time. The order of success in achieving *management objectives* in each group may require sequencing, and deadlines established for each. Completion dates must be ecologically realistic (e.g. recognising natural dynamics).

Clearly, sequencing the achievement of *management objectives* will require orchestrating the decisions and actions of collaborators.

Checklist for CRITERION 4: Ecologically Complete	
"	all parts of an ecosystem, which may affect success in achieving a particular management objective have been considered
"	if success in achieving a particular management objective depends on success in achieving other *management objectives*, these linkages are indicated in each related objective and all are grouped

1.6 CRITERION 5: Accountable

"Accountable" means the assumption of responsibility and commitment to success.

Collaborators should want to succeed. Motivation for accountability may be founded on a general ethical or moral grounds, it may be based on self-interest, it may have a legal basis (e.g. *command and control*), or it may be due to some combination of these. Whatever the underlying reason/s, commitment to success should always be compelling.

Some strategies for ensuring accountability among partners include:

! ensuring that *management objectives* are collaborated by being complimentary and well dovetailed. Unless desired, DO NOT SHOULDER what appear to be the responsibilities of other collaborators.

Successfully managing human activities within an ecosystem requires tailoring, and clarifying the responsibilities of collaborators. Full commitment can be difficult to garner for difficult objectives. Attempts to share or blend in some uncertain way, and thereby

"blur" and diffuse responsibility can echo a lack of commitment to success. Diffused responsibility will not satisfy the accountability criterion. For example, where many collaborators may affect the amount of water available to sustain a particular fish species, each accountable party must know what their contribution to success should be. Securing commitment may require rewording a particular management objective, or creating new ones to improve focus. Where legal overlaps may be unavoidable between some institutional partners (e.g. in responsibilities for water within a watershed management plan), accountability can be assured by negotiating the agreement of lead agencies for *management objectives* of common interest.

Some questions which should be addressed include:

- Will the candidate be fully accountable for success in achieving a management objective?
- Can the candidate commit to accountability? Is the duration of the candidates" commitment to the objective sufficiently long term? Is the commitment transferable within the organization?
- Can lobby groups, legal suits, historical track record/reliability sway the candidate"s accountability?

! ensuring that each collaborator has the necessary implementation means and mechanisms (e.g. Does the candidate have the ability to lever fiscal or human resources needed to execute the partnership?)

! ensuring that accountability for each objective is compelling, reflecting the ongoing responsibilities of the organization or individual who made it

For example, accountability mechanisms for some *management objectives* and related tasks which fall within the realm of governance, already exist for some suggestions about how values, *management objectives* and accountability could be better linked).

! ensuring that legal corrective measures are linked to an objective where possible so, if warranted, these may be used to keep the outcome of management decisions on track

Legal accountability should ensure synergy between legal systems and *management objectives* and the ecosystem. The accountability of agency partners is easily achieved by melding institutional statutory objectives (often stated in the “general provisions” of a statute) and local management needs. This strategy will allow the existing tools of governance to be better focussed and tailored to achieve management success.

Some questions which should be addressed include:

- What are the property rights of the candidate?
- What is the legal authority of the candidate to take corrective actions should their objective/s not be met?

! ensuring that responsibility for achieving an objective is traceable, preferably to a subunit of a particular agency and/or to an individual.

Checklist for CRITERION 5: Accountability

- " the management objective has been formulated for a collaborator who has pledged responsibility and commitment to success
- " the collaborator has the necessary implementation means and mechanisms
- " the collaborator (where possible and desirable) has access to legal means to strengthen and support management responses needed
- " the collaborator (particularly institutional collaborators charged with interpreting the law) will seek to ensure continued synergy between their responsibility for achieving a management objective within an ecosystem and discharging their responsibilities within the legal systems