THE ECOSYSTEM APPROACH TO ECOSYSTEM MANAGEMENT

Andrew M. Crober
94112923

A Senior Honours Thesis Submitted in Partial
Fulfillment of the Degree of
Bachelor of Environmental Studies
(Honours Geography)

Supervisor
Prof. James J. Kay

Department of Geography
Faculty of Environmental Studies
University of Waterloo

June, 1999

TABLE OF CONTENTS

THE ECOSYSTEM APPROACH TO ECOSYSTEM MANAGEMENT

ABSTRACT

Government agencies have adopted an ecosystem approach to ecosystem management as the mandated form for managing ecological systems. This review paper will provide a detailed summary of the ecosystem management debate. The first section will discuss the development of the ecosystem approach, and address the key questions and issues surrounding the ecosystem management debate. The second section focuses on the important principles and themes that should be part of a successful ecosystem management strategy.

There is no precise definition of ecosystem management. In time there will be a need for a precise definition as this will assist managers and policy makers and everyone involved in ecosystem management. However, as ecosystem management is evolving, it should be left to being defined by its for now. That said, it must be acknowledged that ecosystem management be based on the ecosystem approach, an approach based on complex systems theory. Its principles are based on hierarchy theory, self-organization, chaos and catastrophe theories, and non-equilibrium thermodynamics. When thought of in this manner ecosystem management does truly represent a paradigm shift in the management of ecological systems. Ecosystem science should form the basis of ecosystem management, however the role of the social sciences needs to be expanded.

For ecosystem management to be successful the analysis of the ecosystem must be done within the context of an adaptive management process. Further institutional changes are needed if ecosystem management is to succeed. These include organizational change, interagency cooperation and changing the way ecosystem science and management are taught.

1.0 INTRODUCTION

In an effort to adopt a more holistic approach to natural resource and environmental management, government agencies have adopted an ecosystem approach to ecosystem management as the mandated form for managing ecological systems.

Ecosystem management is a rapidly evolving approach to managing ecological systems. To some, it is a profoundly new approach; to others, it is simply a new term for what has been done all along (Irland 1994). The essence of the problem surrounds the need for a precise definition of the term, something that identifies exactly what ecosystem management is, and what it is not (More, 1996). There is a broad range of literature dealing with the ecosystem approach, ecological systems, ecosystem theory and social sciences that illustrates the complexity surrounding the ecosystem management debate. The goal of this paper is to identify and analyze a broad range of literature related to ecosystem management. This review paper will provide a detailed summary of the ecosystem management debate. The first section will discuss the development of the ecosystem approach, and address the key questions and issues surrounding the ecosystem management debate. The second section will focus on the important principles and themes that should be part of a successful ecosystem management strategy.

There is a lack of consensus surrounding ecosystem management i.e. what it is?, how it is practiced, does it represent a paradigm shift? etc. This debate has created uncertainty and confusion among academics, resource and environmental managers and policy makers. The goal of section 1 is to trace the development of the ecosystem approach from its infancy to where it is today, as well as the development of ecosystem management; and to provide an objective view of the ecosystem management debate by identifying the key questions and issues with the hopes of building consensus and points of contention, and therefore increasing the understanding of the ecosystem management concept.

Ecosystem management is the mandated form for managing ecological systems by most government agencies. However, it is an evolving approach and as a result it is important and necessary to come to some sort of consensus as to what it is. The next step is to bring the theory into practice, thus implementing the approach. The focus of section 2 is on outlining and describing the various components, themes, and principles necessary for successful ecosystem management. An analysis of the necessary ecosystem factors and institutional arrangements will be presented.

A precise definition may never be agreed upon as to what ecosystem management is, instead maybe the focus should change to agreeing to a

checklist for good ecosystem management to aid managers and policy makers. Ecosystem management is based on the principles of the ecosystem approach. If thought of in this manner, the solution it would seem is to develop a set of universal principles for the ecosystem approach. Managers can then employ whatever management techniques best achieve the principles of the ecosystem approach. This allows for a flexible management style, an adaptive management approach.

The intent of this paper is consolidate a broad range of literature and provide an objective view of the ecosystem management debate, building consensus and identifying points of contention, taking neither the stance from the natural resource or environmental management communities, or from that of industry or government. The paper will discuss the major issues with respect to ecosystem management, and to provide a recipe of sorts for successful ecosystem management. It is not the intention of this paper to be a 'how to' manual on the ecosystem approach to ecosystem management. In addition to the goals previously stated the following products from this research include a bibliographic database, an annotated bibliography and a physical collection of the set of articles.

2.0 METHODOLOGY OF RESEARCH

The research methodology involved three phases: a search phase; a reading phase; and a synthesis and reporting phase.

Literature Search Strategy

A necessary component of the thesis research is the collection and review of existing literature, projects and programs related to ecosystem management. The search strategy for this study builds upon an earlier database completed by Marie Lagimodiere, a research assistant at the University of Waterloo, that covered literature up to 1993.

There is an overwhelming amount of literature on ecosystem management, as a result it is important to identify a strategy that outlines how the data was collected in order to avoid duplication and increase efficiency in collection.

The following databases were searched for this paper:

- **Environment Abstracts database**

A database indexing approximately 800 international journals and periodicals, as well as books and conference papers, related to the environmental field. Disciplinary areas include environmental studies and management, ecology, geography, architecture, etc. Entries from 1971 to the present are available.

- **Current Contents database**

A multidisciplinary, scientific database that covers thousands of journals in total. The most important journals in each field are selected and reviewed,

and published in weekly issues. The database thus indexes the most recent articles, most of which have not yet been added to other database holdings. Agriculture, Biology and Environmental Sciences (a subset of the total database) was searched for this project from January 8, 1996 to July 1998.

- **Canadian Research Index database**

This database indexes Canadian federal, provincial and municipal government documents, including: research papers in physical, natural and social sciences; policy papers; important statistics; annual reports; and, any paper published by a government department, or sponsored and published through government financial support. Many relevant subject areas are covered, for example: agriculture, commerce and economics, culture, environment, fisheries, forestry, life sciences, natural resources, earth sciences, planning and much more. Entries are available from 1982 through to the present.

- **Geography: An Elsevier Geo Abstracts database**

The information contained in this database is derived from over 1000 leading geographical journals, plus books, conference proceedings, reports and theses related to the environmental field. Disciplinary areas include environmental studies and management, ecology, geography etc. It provides a full bibliographic details of the publications covered plus an informative abstract. This database was searched from January 1990 to February 1998.

Keywords used in searching each of the databases include: ecosystem management; ecosystem approach; ecological integrity; adaptive management; and ecosystem health.

Bibliographies of 'core' material

The bibliographies of documents that are believed to have made an important contribution to ecosystem management, will be used as leads to follow in finding other material. The following documents represent the 'core' bibliographies and include: (Grumbine 1997); (Czech and Krausman's, 1997); (Brunner and Clark 1997); and Fitzsimmons (1996).

Reading Phase

The reading phase simply involved reviewing the numerous articles, reports and books generated from the literature review. A bibliographic database was compiled, as well as an annotated bibliography to provide a list of core and background references for anyone studying ecosystem management. In addition a physical collection of all the journal articles was completed.

Synthesis and Reporting Phase

The synthesis and reporting stage involved an analysis of the literature. Section 1 traces the development of the ecosystem approach; and identifies the key questions and issues with respect to ecosystem management, in the process building consensus and points of contention. Section 2 outlines and describes the various components, themes, and principles necessary for successful ecosystem management. An analysis of ecosystem factors and institutional arrangements is presented.

SECTION 1

3.0 THE DEVELOPMENT OF THE ECOSYSTEM APPROACH[1]

It is important and necessary to start with an historical review of the ecosystem concept in ecology as there is an overwhelming amount of information related to the concept. "The ecosystem has been a key concept in the development of modern ecology, yet today it is widely misunderstood and misused (Golley 1993)" Golley (1993), provides an in-depth review of the ecosystem concept up to about 1975. The first section of this historical review will focus on the ecosystem concept specifically, while the second section will address the historical development of ecosystem management.

The ecosystem concept is over a half century old (T.F.H. Allen and D.W Roberts in Ulanowicz 1997). There was an exact moment of birth for the concept, which occurred when Arthur Tansley coined the term 'ecosystem' and presented it in a technical paper in 1935 (Golley 1993; T.F.H. Allen and D.W Roberts in Ulanowicz 1997). However, prior to Tansley, Transeau in 1926 worked on energy budgets using a cornfield and an orchard as his material system of interest, thus employing a new conception of an ecological system. The emphasis on flux and process as opposed to place and organism was a departure from previous approaches (T.F.H. Allen and D.W Roberts in Ulanowicz 1997). Raymond Lindeman, less than a decade later applied the term in his study of the trophic dynamics of Cedar Bog Lake (T.F.H. Allen and D.W Roberts in Ulanowicz 1997; Golley 1993). Lindemans work ushered in a period of growing interest in ecosystem studies, he still focused on species, but the whole system was characterized as a system with energy flowing through it (Golley 1993). Eugene P. Odum used the ecosystem concept as an organizing concept, where energy and mineral flux served as a descriptive

[1] Note added by J. Kay. The history provided here depends largely on American sources. As such it does not document much earlier developments in Europe and Canada, particularly with respect to initiatives around the Baltic Sea and the Great Lakes by the International Joint Commission. See for example: Lee, Brenda J.; Regier, Henry A., and Rapport, David J. Ten Ecosystem Approaches to the Planning and Management of the Great Lakes. J. Great Lakes Res. 1982; 8(3):505-519. and Bocking, S. "Visions of Nature and Society: A history of the eocsystem concept", 1994, Alternatives, Vol 20, No.3, pp12-18

device, and provided a new set of properties pertaining to overall system organization (T.F.H. Allen and D.W Roberts in Ulanowicz 1997). Odum's use of the concept lead to a rapid increase in ecosystem studies and its theoretical development. Today we are finally approaching an account of the general properties of ecosystems that use the common currency of thermodynamics. The process of development of the ecosystem concept lead to the institutionalization of ecosystem studies in the International Biological Program (IBP). The IBP never achieved it goals and objectives , but the process of institutionalization lead to the maturing of ecosystem studies. F. Herbert Bormann and Gene E. Likens research at their Hubbard Brook , New Hampshire site, studied the ecosystem as an object to discover how it was constructed, how it functioned, and how it responded to disturbance and stress. These studies became models for other ecosystem programs and became a source of data for environmental management (Golley 1993).

The more recent research has focused the thermodynamic properties of ecosystems, using hierarchical thinking to deal with the complexity of ecological systems. There are numerous researchers in the ecological field who are pursuing this line of research; the following people represent some of the seminal researchers in this field; Tim Allen and Tom Hoekstra's (1992) research efforts demonstrate an explicitly hierarchical position, examining various levels of organization, naming each one an ecological criterion.- the ecosystem being on of those criteria; and Robert Ulanowicz's research efforts focus on ecosystem thermodynamics using hierarchical thinking.

In describing the historical development of ecosystem management many believe that the concept is not limited to the establishment of the term "ecosystem" in the literature and that a much larger body of literature could be accessed to address this subject matter (Czech and Krausman 1997). According to Czech and Krausman (1997), the development of ecosystem management begins with Schultz' 1967 discussion of the ecosystem as a conceptual tool in natural resources management. Grumbine's (1994) paper also traces the historical development of the ecosystem management concept, highlighting the American perspective. He cites the works of the Ecological Society of America's Committee for the Study of Plant and Animal Communities in 1932 that recognized that a comprehensive U.S. nature sanctuary system must protect ecosystems as well as particular species of concern, represent a side range of ecosystem types, manage for ecological fluctuations and employ a core reserve/buffer zone approach. The Committee also recognized the need for interagency cooperation. Grumbine then discusses the contributions of biologists George Wright and Ben Thompson and their classic study "Fauna of the National Parks of the U.S." that observed that parks were not fully functional ecosystems by virtue of boundary and size limitations. He then acknowledges Aldo Leopold's contributions in conservation science and philosophy; Lynton Caldwells 1970 publication that advocated using ecosystems as the basis for public land policy; biologists

Frank and John Craigheads research on grizzly bear populations that demonstrated that the bears' needs could not be met solely within the borders of Yellowstone National Park. According to Grumbine the first book-length treatment of ecosystem management appeared in 1988 courtesy of Jim Agee and Daryll Johnson, entitled 'Ecosystem Management for Parks and Wilderness. In the book they discuss the need for ecosystem boundaries, interagency cooperation, and monitoring. Since that publication their has been numerous papers examining all aspects of the ecosystem management concept.

4.0 THE ECOSYSTEM MANAGEMENT DEBATE

Ecosystem management is a tremendously complex issue, few areas of public policy are as contentious as it is (Haeuber and Franklin 1996). The issues and questions surrounding the debate are as much political, economic, social and cultural as they are ecological. The Ecological Society of America (ESA) summarize the debate well when they say that 'while the scientific community can establish the validity and reliability of various ecosystem management practices, their applicability and feasibility are perhaps more closely linked with social and political approval then technical viability (Haeuber and Franklin 1996 p 692).

The purpose of this chapter is to demonstrate the complexity of the ecosystem management debate by providing an overview of some of the key issues and questions that have emerged from a review of the literature.

To start with, a discussion on identifying 'what is ecosystem management?' will be presented and why it is so difficult to define; followed by a discussion on whether there really is a need for a precise definition. This will then be followed by an examination of whether the ecosystem management concept represents a paradigm shift, or in other words, is it merely a new term for what has been done all along or does it truly represent a shift from the traditional form of managing ecological systems? The debate on ecosystem management will conclude with a discussion on the roles of social sciences and ecological sciences.

4.1 What is ecosystem management?

What is ecosystem management? This heading appears often throughout the literature on the topic. The need to pursue this line of questioning stems from the lack of a precise definition of ecosystem management. In many federal, provincial and state agencies as well as non-government organizations (NGO's), ecosystem management has become the mandated form for managing ecological systems. Since there is little agreement on a precise definition, shifting ecosystem management from theory into practice (implementation) has not been consistent throughout the various agencies. There are numerous reasons identified from a review of the literature that illustrate why ecosystem management is so difficult to define. Before a

discussion is started on this however, here is a sample of the various definitions that exist:

- Grumbine (1992) Any land management system that seeks to protect viable populations of all native species, perpetuate natural disturbance regimes on the regional scale, adopt a planning timeline of centuries, and allow human use at levels that do not result in long-term degradation.
- Grumbine (1994) Integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework towards the general goal of protecting native ecosystem integrity over the long-term.
- International Joint Commission (1994) Is an active process that emphasizes the maintenance of biological diversity, of natural relationships among species, and dynamic processes that make ecosystems sustainable.
- Wrona (1994) Recognizes there are ecological, social and economic considerations to be made when assessing and predicting the impacts of human activities on natural systems and practicing the 'ecosystem approach' means that all stakeholders understand the implications of and are accountable for their actions.
- Cortner et al (1994) A management philosophy which focuses on desired states, rather than system outputs, and which recognizes the need to protect or restore critical ecological components, functions, and structures in order to sustain resources in perpetuity.

This diversity of definitions stems from the fact that "definers commonly couch their definitions in terms of their own values, and it is the differences in individuals and group values that produce the definitional differences (Wagner in Jensen et al 1996). Simply put, those interested in environmental protection and conservation emphasize the values of preserving biodiversity, ecosystem health and integrity and sustainability in their definitions of ecosystem management; while on the other hand those in industry (timber) tend to use ecosystem management to politically justify increasing natural resource exploitation (Grumbine 1994). Therefore as Wagner suggests, ecosystem management is the "skillful manipulation of ecosystems to satisfy specified societal values."

More (1996) describes the essence of the problem of defining ecosystem management in this way "How can short-term, for-profit timber sales be placed in the same category as a long-term ecological restoration project? How can all the disparate management activities of foresters, wildlife biologists, fisheries managers, or landscape architects be brought together under the single heading of ecosystem management? And in such a situation, how can the basis of scientific management be preserved? (More 1996, p 20)" More, states that part of the difficulty is the complexity of the various definitions that exist. However, another problem concerns how

complex concepts are defined and what are expected of such definitions. To address this problem More (1996) presents a discussion on the different types of definitions that exist, namely classical and prototypic. A classical definition he claims should specify both the essence of ecosystem management and its boundaries so that we can decide immediately if a particular activity is or is not an instance of ecosystem management. Classical definitions he says offer a "comforting exactitude". Unfortunately, few things in life fit this mold. Consequently the notion of prototypic definitions was developed to be used with fuzzy concepts. More (1996) use the following illustration to best describe a prototype. "Suppose you decide to paint a room yellow, when you get to the paint store, the first thing that strikes you is the huge array of different yellows. Although they are all yellows, specific examples can look quite different, and there will be instances where one has to look closely to determine if the colour is really yellow. This seems more like ecosystem management (More 1996, p 21). More continues, saying that it is for this reason that two projects that are very different can be considered ecosystem management, just like a greenish yellow or brownish yellow are all different, yet still yellow. More (1996) concludes by saying that in a sense, the descriptions of ecosystem management in practice are really attempts to define the prototype.

Another explanation for the difficulty in defining ecosystem management is due to the vagueness of the concept. As Wilcove and Blair (1995) express "when environmentalists hear ecosystem management, they hear 'ecosystem'; while the timber industry hears 'management', and to them that means cutting lots of trees. The vagueness of ecosystem management, its ambiguity, is an obstacle to defining it, however as Salwasser (1994) explains, "if ecosystem management is to work, people will need a common understanding of what ecosystems are… and beyond that we need a common understanding of how they work if the 'new' management concept is to be successful (Salwasser 1994, p 7). In addition to understanding what ecosystems are, consensus also needs to be built around two other key terms related to ecosystem management - ecosystem integrity and ecosystem health. At this time in the evolution of ecosystem management these term remain vague and also have been defined in several different ways.

As Wilcove and Blair (1995) state, "Ultimately ecosystem management will be defined in actions , not words" and as a result they feel the most pressing challenge is to develop a set of clear and measurable goals that indicate success or failure - these goals could form the basis for conservation planning in many countries. This leads into the next question 'is there really a need for a precise definition?'

4.2 Does Ecosystem Management Need to be Defined?

According to More (1996), the answer is no. Many everyday concepts are fuzzy-sets with no clear-cut prototype. Ecosystem management is a fuzzy concept

that contains practices, techniques, goals and objectives that share overlapping attributes or characteristics. It is defined through these characteristics, any one of which may or may not be present in a particular project. None of these characteristics alone can define ecosystem management, nor need all, or even most be included (More 1996).

Czech and Krausman take a different view, saying that ecosystem management is a catch-all concept, that "ecosystem" and "management" are comprehensive terms in their own right. Furthermore neither is new and neither is vague. Both are well understood by ecologists, managers, policy makers, and much of the public, and for the purposes of linguistic clarity then, the phrase ecosystem management requires no definition.

Tarver (1995) asks why we are quibbling over words, when our role in giving it meaning is what is really important. He states "ecosystem management is not defined. It is not a prescription; it is not even a process. It is simply a label for an attitude about resource management, one which widens and deepens our thinking about our actions. There is no single correct definition."

The concept of ecosystem management is evolving, and as Jensen et al (1996) state, it would be counter-productive to hasten to an all inclusive definition that could limit further philosophical development. It is obvious therefore that many in the resource and environmental management community (Wilcove and Blair 1995, Tarver 1995, Jensen et al 1996) do not find cause for alarm, and in fact feel it is advantageous that there is no precise definition; a definition will emerge with time.

According to More (1996), this claim has some validity, but also substantial risk. Grumbine (1994), and Huff (1995), echo these concerns. Both Grumbine and Huff note that ecosystem management has not been consistently applied across agencies and by others committed to improving the environment, due to the lack of a precise definition. Huff goes on to say that a scientifically derived definition for ecosystem management is essential as it represents the cornerstone of all natural resource professions. "Ecosystem management applied without defined principles can hardly be considered scientific", claims Huff. He also acknowledges that the absence of a definition leaves a major gap between concept and application so that many legitimate agency practices may be excluded.

4.3 Does ecosystem management represent a paradigm shift?

The problem in answering this question stems from the fact that there is no precise definition of ecosystem management. Therefore, it depends on how one defines ecosystem management as to whether or not it represents a paradigm shift. A review of the literature shows two distinct views: 1) ecosystem management and its principles have existed for sometime in natural resource and environmental management and is simply a new term

for what has been done all along; 2) ecosystem management does represent a new way of managing ecological systems.

Salwasser (1994), Czech (1995), Knight (1995), Gerlach and Bengston (1994) and Wenger (1997) all agree ecosystem management is not a new concept. Salwasser (1994), Czech (1995) and Knight(1995) discuss how Aldo Leopold demonstrated the principles of ecosystem management more than 40 years ago. Salwasser cites Leopold, saying "that people should take care of the land as a whole organism, and try to keep all the cogs and wheels in good working condition (Salwasser 1994 p?)." Therefore Leopold was implying that we must sustain the diversity and productivity of ecosystems while meeting peoples needs for livelihood - today this is called ecosystem management, says Salwasser. Knight (1995) discusses how ecosystem management asks stewards to manage lands for commodities, amenities and importantly, native biodiversity and illustrates that Leopold anticipated this idea over 40 years ago when he developed the concept of a "land ethic." Gerlach and Bengston (1994) claim ecosystem management is not a new concept citing the work of Major (1969). They outline and discuss 11 challenges for ecosystem management for which they hope will broaden the ongoing debate. Wenger (1997) discusses several steps in the ecosystem management process - a description and inventory of the ecosystem, selection of the management objective - he then goes on to say that "if this sounds very much like what is already being done, it is. Czech (1995) notes that Leopold stressed the importance of ecological states compared with the consumption of outputs, and cultured a philosophy based on a perception of ecological processes. Czech claims that although Leoplod never actually used the term ecosystem management, his career testifies that he recognized the need to protect or restore ecological components, functions and structures in order to sustain resources. Czech (1995) provides an in-depth look at whether or not ecosystem management represents a paradigm shift. According to Czech (1995), ecosystem management, no matter how it is defined cannot be the new paradigm as none of its principles are new and that natural resource professionals have essentially been practicing it for a long time without "desired states" or socially desirable conditions they have sought. Czech (1995) then moves to a discussion on whether or not a new paradigm is available. He discusses what is needed to cause a paradigm shift, namely a shift in human values. Czech concludes by proposing a renaming of ecosystem management to ecosystem conservation with the hopes and beliefs that this would best effect a positive paradigm shift or in other words would most positively change societal values regarding the management of ecological systems.

Fedkiw (1997) and Gilmore (1997) both feel ecosystem management is still somewhere in its growth curve, implying that its evolution is not complete. Fedkiw (1997) states the evolution in managing multiple uses on national forests suggest an incremental ecosystem approach and that we have been

on this pathway since the passing of the Organic Administration Act. Gilmore (1997) discusses how resource management has evolved through 4 major phases each increasingly more sophisticated. Discussed are the exploitive phase, an administration phase, an ecologically-based phase, and a social phase. The ecologically-based social approach to resource management is currently being called ecosystem management. According to Gilmore (1997) this differs fundamentally from the multiple use philosophy of the 1960's and 1970's in that all components of the ecosystem, including people , must be considered as integral parts of the management planning process. Ecosystem management is distinctive in that it includes a public participation process to provide a societal context for resource management decisions. Although Gilmore says ecosystem management represents a fundamental change from the multiple use concept, it has evolved in the midst of three competing value systems: 1) the resource conservation ethic; 2) the preservation ethic; and 3) the ecological-evolutionary land ethic of Leopold.

The other argument that emerges from a review of the literature is that, yes, ecosystem management does represent a new paradigm, a new way of managing ecological systems. However, the reasons that make the ecosystem-based approach to management a paradigm shift are varied.

A common reason is that ecosystem management represents a shift from a species approach for achieving sustainability to a systems approach that emphasizes the whole ecological system, its processes and functions. The following researchers represent some of the most influential people related to the study based on systems theory. According to Allen and Roberts, "Complex systems analysis is a new way of maintaining coherence during challenging ecological investigations that follow from pressing contemporary issues (in Allen and Hoekstra 1992, p xiv)." According to Kay and Schneider (1994a), "there are a group of thinkers who argue that to deal with ecology requires an ecosystem approach, an approach based on the notions of complex systems theory, a subset of general systems theory. It is a fundamentally different approach to knowing about the world. Any effort to study such complex systems, must look at them in the context of space, time, energy and information. (Kay and Schneider 1994a, p 34)" Thermodynamics investigations and analyses with respect to ecosystems is the context in which the systems approach is applied. Kay (1991),Pahl-Wostl (1995), and Ulanowicz (1997) all focus on the thermodynamics of ecosystems. Holling (1996) focuses on the dynamics of ecological systems, including processes responsible for both increasing organization and for occasional disruption. Holling pays special attention to the prevalence of discontinuous change in ecological systems and to specific non-linear processes interacting on multiple time and space scales. It is the focus on the thermodynamics, non-linear and non-equilibrium processes that these researchers feel truly sets the ecosystem approach apart from previous management approaches of ecological systems.

Alpert (1995), states that single natural resource management (maximum yield of timber) and its successor, multiple resource management (optimal combined yields of timber, forage, recreation and other resources) have in principle been replaced by natural systems management - where the system itself is the only sustainable resource.

Grumbine (1994), acknowledges a systems perspective in his ten dominant themes of ecosystem management, but feels it is the five specific goals of sustaining ecological integrity that provide a striking contrast to the goals of traditional resource management. These goals include: 1) maintaining viable populations of all native species in situ; 2) represent within protected areas, all native ecosystem types across their natural range of variation; 3) maintaining evolutionary and ecological processes (i.e. disturbance regimes, hydrological processes, nutrient cycles etc.); 4) manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems; and 5) accommodate human use and occupancy within these constraints.

Irland (1994), says ecosystem management certainly poses a new paradigm for managing forests, as its focus on landscape conditions and trends changes our approach to ownership distinctions.

Galindo-Leal and Bunnell (1995) briefly review the dramatic shift from a single species approach to a multi-species, ecosystem approach.

Others such as Knight and Meffe (1997), highlight how ecosystem management has lead to changes in agency attitudes and behaviours, because ecosystem management encourages partnerships, cooperation and risk-taking, contrasting sharply with the linear command and control approach of traditional resource management that encouraged hierarchical decision-making. Knight and Meffe (1997) outline the following comparison of management perspectives in natural resource agencies driven by the traditional command and control approach versus the ecosystem approach.

TRADITIONAL MANAGEMENT	**ECOSYSTEM MANAGEMENT**
• top-down decision-making	• input from all levels
• centralized, linear	• decentralized, with feedbacks
• risk aversive	• risk-taking
• finality of decisions	• willingness to revisit, revise and admit error
• imposed vision	• shared vision
• within administrative boundary	• across administrative boundary
• control	• partnerships

(Knight and Meffe 1997, p 677)

Taylor et al (1995) emphasize the ecosystem paradigm from the perspective of university studies. They claim the philosophical shift from a single species approach to an ecosystem view of management problems means that future fishery professionals must understand the physical, chemical, biological and social components of the ecosystem, the linkages among each component, and how these components relate to productive sustainable fishery resources.

Allen (1997), argues ecosystem management differs markedly from past management both in theory and in practice, and discusses how the differences have expanded the role for social sciences.

Clearly within the ecosystem management community there remains philosophical and practical differences as to why ecosystem management is a paradigm shift. These different view points arise based on how ecosystem management is analyzed. From a scientific perspective ecosystem management is a new paradigm because it represents a new way of thinking in ecological theory; from a non-scientific view, ecosystem management represents a new paradigm because of how it influences attitudes and behaviours, changes organizational structure, and ownership distinctions, as well as addressing other implications for social sciences. This brings us to the final section in the debate of ecosystem management - the role of ecological sciences versus the social sciences.

4.4 The Roles of Ecological and Social Sciences

Successful ecosystem management requires both expertise from the ecological and social sciences. There is little question about this. A review of the literature on the topic however, illustrates there is controversy about which of the two sciences is more critical to its success. The debate centers around which science should be the basis for ecosystem management.

Ecosystem science is critical to the success of ecosystem management, this is obvious. According to Carpenter (1996), “all the speakers at the Symposium on Ecosystem Management regarded ecosystem science as a foundation for ecosystem management, which bridges the basic sciences on how the natural world works and the more applied sciences of how human society makes decisions for increasing the welfare of its members. Carpenter (1996) summarizes the argument for ecological sciences best, saying social sciences are often emphasized at the expense of natural resources…everyone especially decision-makers are amateur social scientists. In contrast the technical aspects of ecologists are impersonal, unfamiliar to many, and only specialized trained professionals can discuss them. Lay persons feel more comfortable with verbal arguments than quantitative information and therefore gravitate to the discourse of social science rather than wrestling with understanding natural science information. He continues by saying, “robust ecological theory, well understood biophysical relationships, and status and trend monitoring data are the foundation for all

other considerations in ecosystem management." The most important task for environmental scientists lies in putting into practice some form of adaptive ecosystem management, improving management practices and reducing uncertainties about stress response. Carpenter ultimately feels that the ecological science community most demonstrate its capability and readiness, explain the biophysical foundation for ecosystem management, outline and advocate a research and monitoring strategy and take the lead in an association with federal agencies. The ESA report summarizes the role that formal ecological science can play with respect to ecosystem management, reviewing the importance of sustainability, the dynamic nature of ecosystems, the role of ecology in management, the limitation of human knowledge, and the role of humans in ecosystems.

In reviewing the recent literature, however, much more attention is given to aspects of social science including, public participation, interagency cooperation, organizational and institutional change, values etc.

Cooperrider (1996), questions the proposal that science be the model for ecosystem management. Asking questions such as: What type of science will it be? What questions will it be addressing? Who will be doing it? How will it be integrated into society? Cooperrider finds the major problem with modern conservation efforts to be the fragmented approach to biological conservation, for example that only certain human actions (those that applied ecologists are accustomed to studying) are dealt with. He concludes that science is neither a panacea nor a problem in itself. Instead what is needed is for scientists to take a more value-driven holistic and inclusive approach to science than now exists. "We cannot leave it to the experts (Cooperrider 1996, p737)."

Salwasser (1994), states that first, "ecosystem management is more about people than anything else…the success or failure of ecosystem management in protecting environments, revitalizing economies, or restoring healthy communities starts and ends with people and their choices - not with nature preserves, databases, ecological classifications, or any other technological tools that are merely useful means to desired ends ; and second, ecosystem management is based on ecological principles (Salwasser 1994, 10).."

Allen (1997), highlights the expanding role for social science. He discusses how ecosystem management requires increased understanding of social and economic systems and their links with biophysical systems. For example ecosystem inventories require inventories not just of flora and fauna, but also of such conditions as past and present use of natural resources, economic and non-economic values associated with those uses and peoples knowledge and attitudes regarding national forests.

Marcin (1995), argues that "we need much more accurate knowledge about what public attitudes are and how they vary by socio-economic factors of age, education, income, and social class …more importantly we need to know why expressed attitudes are held and what the trade-offs are between cultural attitudes toward environmental protection and economic gain from the use of resources. Marcin (1995) feels the social sciences in particular should play a more prominent role in the analysis of research and decision-making.

Kerr (199?), states that "to assume that managers will not politicize the reasoned and objective recommendations of science ignores history and guarantees that science will be abused rather than used in making public policy. Scientists must enter the public policy arena to ensure that managers use their recommendations correctly (Kerr 199?, 378)."

Alpert (1995) discusses how social scientists seek better ways to accommodate community-based concerns in ecoregion assessments, forest plans and other broad-scaled efforts; how social scientists can also play an important role in accomplishing increased collaboration with public land stakeholders, as well as providing techniques for measuring its success; and how social scientists are developing and refining techniques for conducting place assessments and their application for ecosystem management.

As Grumbine (1994) notes, the ecosystem management debate is really a complex, competitive, conflictual social process about what values will dominate, it is not about science. He also says "this emphasis on science is an artifact of the training and professional norms of the major group writing about ecosystem management - scientists…defining ecosystem management goals is also a political process. (Grumbine 1994 p33)." Ecosystem management according to Grumbine needs lawmakers to revisit and strengthen key environmental laws, policy-makers must successfully confront issues of population growth and resource consumption, fostering cooperation and opening up the decision-making process is also needed. None of these can be solved by (ecological) science.

4.5 Perspectives on the Ecosystem Debate

A precise definition of ecosystem management cannot be formulated at this stage in its evolution. There are numerous perspectives as to what ecosystem management is, what it should do, and how it should be implemented, but really there is no consensus, even though according to Grumbine (1994) there is. Yes there are many themes and principles of ecosystem management that are agreed upon in the literature such as, adaptive management, ecological integrity, the need for monitoring, data collection, the role of humans as part of the ecosystem etc. However, there is still so much uncertainty and confusion regarding the topic. In my opinion any definition of ecosystem management must acknowledge the ecosystem approach as this is the basis of ecosystem management. The ecosystem

approach is an approach based on complex systems theory (Kay and Schneider 1994a). Its principles are based on hierarchy theory, self-organization, chaos and catastrophe theories, non-equilibrium thermodynamics etc. Therefore, ecosystems must be recognized as dynamic, not deterministic, as having a degree of unpredictability, and exhibiting phases of rapid change (Kay and Schneider 1994a). In reviewing the literature there is relatively little attention given to this in treatments of ecosystem management, compared to the vast amount of literature on the subject. Ecosystem science must form the basis of the ecosystem approach to management, but the social sciences must play an expanded role if ecosystem management initiatives are to be implemented effectively. For a definition of ecosystem management, and ecological integrity for that matter to be useful it must be scientifically defensible and operationally useful. This is where ecological science and the social sciences must really work together. The lack of consensus in the ecosystem science community is a major obstacle to implementation, as is the lack of social scientists dealing with ecosystem management initiatives.

As will become evident in the next section the ecosystem management debate does represent a paradigm shift. However it only represents a paradigm shift if one takes a thermodynamic perspective of ecosystems function and processes. According to Pahl-Wostl (1995), it is the burst of interest in the dynamics of non-linear systems in recent years that truly makes the ecosystem approach a new paradigm. It appears that many of the writers on "ecosystem management" do not acknowledge this or at least make it explicit in their writings. Yes, hierarchy theory and systems theory are addressed by several authors, but very few, Holling, Kay, Pahl-Wostl to name just a few deal with the notion of ecosystems as self-organizing entities. This provides an interesting perspectives on ecosystem functioning that will ultimately enhance management capability and capacity. As time passes and research expands it is this thermodynamic, non-equilibrium perspective of ecosystems that will eventually make ecosystem science a respected science of management.

SECTION 2

5.0 TOWARDS SUCCESSFUL ECOSYSTEM MANAGEMENT

The following discussion is not meant as a how-to-guide to implement ecosystem management initiatives. Instead it is an overview of what I feel is essential when applying the ecosystem approach to ecosystem management.

The first part of the discussion will focus on analyzing the ecosystem under study for management purposes. The steps applied in this approach are based heavy in the emerging ecological science briefly discussed in the last section, as well as incorporating aspects of social science. The second section discusses the key institutional arrangements necessary for successful ecosystem management. For discussion sake these two

elements are treated separately, however any strategy must integrate these components effectively.

5.1Ecosystem Analysis

In the first section, the discussion will be based around Kay's (1994a) framework used on the Huron Natural Area. It applies the steps of the ecosystem approach using a thermodynamic perspective to analyze ecosystems. The steps are outlined as follows:

1. Defining the ecosystem
2. Describing the ecosystem as a self-organizing entity
3. Evaluating ecosystem integrity
4. Is this integrity threatened
5. Maintaining ecosystem integrity

Step one involves defining the ecosystem. This can be a difficult task as the term ecosystem, like the term ecosystem management can have various meanings depending upon the user. This is why a precise definition that is operationally useful and scientifically defensible is needed. Gonzalez (1996) feels a place-based or ecosystem approach to management requires such a definition. He proposes the following definition:

> "A volume of land, air, and water with natural boundaries, delineated primarily by landscape features and climatic factors. It encompasses a set of natural ecological processes, organisms, and anthropogenic processes that function within a nested hierarchy of volumes (Gonzalez 1996, p598)."

According to Gonzalez this definition has two advantages. One, it is functional within a spatial and temporal hierarchy of ecosystems; and two, it is landscape-based therefore boundaries can be delineated in the field and on maps with a fair degree of permanence. Although Allen and Hoekstra (1992), do not surrender to this notion that entire ecosystems can be mapped onto places on the landscape for a workable duration of time, Gonzalez's definition is a good start.

When defining an ecosystem it is necessary to understand that an ecosystem is a term applied across a wide variety of spatial scales. Functionally as well as spatially, ecosystems exist in a nested hierarchy. The higher levels contain and are composed of all ecosystems at lower levels (O'Neill et al in Gonzalez 1996). Gonzalez illustrates that ecosystem boundaries can be both structural and functional: If the differences found between on side of a boundary and the other are significant, then the boundary is true, or natural. If the differences are not significant, than the boundary is artificial and may not define separate ecosystems.

Hierarchy theory provides a useful and needed framework of the description of the components of an ecosystem and their scaled relations (Jensen et al 1996). Jensen et al (1996) provide a brief outline of four key principles of hierarchy theory that are required for an understanding of landscape patterns and their dynamics:

1) The whole/part duality of systems states that every component of a system, ecological or otherwise, is a whole and a part at the same time. For example, a forest (a whole) is made up of trees (the parts). However, at larger spatial scales, the forest is part of a regional landscape. In that case, the regional landscape is the whole and the forest becomes a part.

2) Patterns, processes, and their interactions can be defined at multiple spatial and temporal scales. These scales need to be clearly identified.

3) There is no single scale of ecological organization that is correct for all purposes. This is an important consideration because scientists often provide information/interpretations on ecological systems at a single or limited number of scales.

4) The definition of an ecological hierarchy is dictated by the objectives of a study or planning endeavor.

Now that a brief review of some of the key principles of hierarchy theory has been provided, I will now review the questions Kay (1994a) asks when defining an ecosystem.

Kay starts with addressing the hierarchical perspective and asks ‘What is a part of what?’ To answer this he defines the nested hierarchy of living systems. Next, the scale and extent of the ecosystem are examined, asking ‘Where things begin and end?’ This requires identifying the boundaries of observation, the processes which define the whole and the boundaries of the ecosystem itself - the holon of focus. The final step in defining the ecosystem is to identify the links or connections in the nested hierarchy of living systems.

Defining ecosystem boundaries can be very difficult but, both Bailey (1996) and Gonzalez (1996) agree that climate is a major factor in delineating ecosystem boundaries.

Climate controls ecosystem patterns at varying scales, as a result basing ecosystem boundaries on climate allows for permanent boundaries to be identified which allow ecosystems to be recognized regardless of condition (Bailey 1996).

Gonzalez (1996) proposes a scheme for delineating ecosystem boundaries that takes a few steps farther than climate. According to Gonzalez (1996), climate and hydrology are the two most important factors, as these most closely represent the true borders of ecological processes of interest. Another factor to further delineate ecosystem boundaries is dominant land use (i.e. agricultural, urban, industrial etc.), and although artificial, political boundaries may also be needed.

The next step is describing the ecosystem as a self-organizing entity. In reviewing the literature on ecosystem management, I could find very little information on this topic. From my review, the two seminal authors on this topic are C.S. Holling and James Kay. The development of self-organizing systems is in accordance with the laws of thermodynamics For a more in-depth review of this topic see Kay (1991, 1994a,b); Kay and Schneider (1994a,b); Holling, (1986, 1993); and Pahl-Wostl (1995)[2]. Here is a brief overview of some key principles regarding self-organization in ecosystems:

> The theory of non-equilibrium thermodynamics suggests the following basic rules of the self-organization process in ecosystems: a) captures more resources (exergy and material); b) makes more effective use of the resources; c) builds more structure; d) enhances survivability (Kay 1994b).
>
> Self-organizing systems get enough energy, but not too much. If they do not receive enough energy then the system is incapable of self-organization. If too much energy is received by the system, chaos ensues and organization falls apart. Therefore self-organizing systems exist in the middle ground, where they receive enough energy, but not too much. Self-organizing systems represent an optimum in terms of functioning, neither maximizing nor minimizing their functions. As more high quality energy is pumped into a system, more organization emerges to dissipate energy. Self-organization in ecosystems is a dynamic ongoing balancing act striving for the middle ground. The only static equilibrium stable state for living systems is death. (Kay and Schneider1994a; Kay 1994b)

To take this theory of self-organizing ecosystems and use it in analyzing real ecosystems Kay (1994a), uses non-linear models, and identifies the attractors and their domains to determine what direction the ecosystem will tend to develop. He then determines the ecosystem behaviour, for example whether it is a stable, homeostatic, or chaotic system. He then determines whether there are bifurcation points, and identifies what the potential flips between the attractors are. The final step in analyzing ecosystems as self-organizing

[2] Note added by James J. Kay: The following WWW site contains more recent references related to this topic. www.fes.uwaterloo.ca/u/jjkay/about/ecosys.html

systems is to assess how the energy, exergy, information and environmental conditions in space and time shape the ecosystems.

The next three steps focus on ecosystem integrity. Understanding ecological integrity requires understanding the Holling "figure eight" model of an ecosystem. Holling (1992) describes the Holling 'figure eight' as follows: The Holling 'figure eight' expands the traditional view of ecosystem succession, which was characterized by two functions: 1) exploitation, in which rapid colonization or recently disturbed areas is emphasized; and 2) conservation, in which slow accumulation and storage of energy and material is emphasized; to now include two additional functions: 3) release, or creative destruction, in which the tightly bound accumulation of biomass and nutrients becomes increasingly fragile until it is suddenly released by agents such as forest fires, insect pests, or intense pulses of grazing; and 4) reorganization, in which soil processes of mobilization minimize nutrient loss and reorganize nutrients to become available for the next phase of exploitation.

"This progression of this birth, growth and storage, death and renewal cycle proceeds from the exploitation phase, slowly to the conservation phase, very rapidly to release and reorganization, then rapidly back to exploitation. Connectedness and stability increase, and a 'capital' of nutrients and biomass is slowly accumulated during the sequence from exploitation to conservation. The system eventually becomes overconnected, so that rapid change is triggered. The agents of disturbance might be wind, fire disease, insect outbreak or a combination of these. The stored capital is then released and the system loses its tight organization, to permit renewal of the same stable state. That pattern is discontinuous and is dependent on the existence of changing multi-stable states that trigger and organize the release and reorganization functions. Resilience and recovery are determined by the release and reorganization sequence, whereas stability and productivity are determined by the exploitation and conservation sequence (Holling 1992, p 481.")

In step 3, Kay (1994a) evaluates ecosystem integrity. He asks what the acceptable states of ecosystem organization are? To assess the integrity, ecological processes at each nested level in the hierarchy must be identified and measured to determine value or need. Finally, identification of attractors that represent unacceptable ecosystem conditions must be done.

In step 4 Kay assesses whether the integrity is threatened. He asks what the external forces which could effect the organizational status of the system are? This is done using an ABCE (abiotic, biotic, cultural and energetics) methodology. Next, he asks what the thresholds of flips to the unacceptable attractors are, or the states of ecosystem organization.

In step 5, Kay identifies how to maintain ecological integrity in a system. Three questions are posited: How to mitigate known threats; how to promote positive influences; and how to monitor the ecosystem so as to detect changes due to previously unidentified external influences.

This completes the ecosystem analysis. However, for this process to be of use, it must be integrated with the various institutional arrangements to be described in the following section. They include the need for adaptive management, organizational change and interagency cooperation.

5.2 Institutional Arrangements

If there is one thing that is certain about ecosystem science, it is that human understanding of it is limited or imperfect, and therefore a great deal of uncertainty exists regarding the management of ecological systems.

As a result, adaptive management has been proposed to deal with the uncertainty surrounding the complexities of ecosystem management. What is adaptive management? According to Lee (1993), "adaptive management applies the concept of experimentation to the design and implementation of natural resource and environmental policies. An adaptive policy is one that is designed from the outset to test clearly formulated hypotheses about the behaviour of an ecosystem being changed by human use…if the policy succeeds, the hypothesis is affirmed. But if it fails, an adaptive design still permits learning, so that future decisions can proceed from a better base of understanding (Lee 1993, p 53)." According to Haney and Power (1996), the process begins by "compiling information related to ecological, socioeconomic, institutional, and cultural issues of each specific management unit. Second, goals or aims of management in each ecosystem are laid out in some detail. Specific priorities and potential problems should be noted. Third, a model composed of working hypotheses is formulated. The model and its components hypotheses should predict how various management options will effect the ecosystem and its socioeconomic and cultural attributes. Site prescriptions are then written and implemented based on the outcomes predicted by the model. This is followed by monitoring to document and analyze social and ecological responses to the chosen management practices. A reassessment of model predictions and a revision of the model and databases precede the next cycle (Haney and Power 1996, p 879)."

The adaptive management process is necessary for successful management of ecological systems. It provides the best opportunity for choosing the best management action. Poor decisions are made everyday in every line of work, however when dealing with complex systems, especially ecosystems, the risk of making the wrong decision, or at least a poorer decision, increases. Adaptive management allows us, however to learn from these mistakes and

incorporate this new knowledge in future decision making processes to avoid previous pitfalls.

Adaptive management does provide much promise in dealing with environmental and natural resource policies, however, due to its very nature one must be aware of its potential risks. Experiments can bring surprise, but if ecosystem management is recognized to be inherently uncertain, the surprises become opportunities to learn rather than failures to predict (Lee 1993).

Traditional resource and environmental management doesn't reward for flexibility, openness, and willingness to experiment, monitor and adapt. However, adaptive management does challenge and is thus risky because new learning challenges the status quo (Grumbine 1997).

According to Grumbine (1997) the adaptive management challenge is to make practioners more responsive to change, to institutionalize new learning.

McLain and Lee (1996) illustrate through several case studies how adaptive management falls far short of knowledge acquisition rates, enhancing information flow among policy actors, or providing opportunities for creating shared understandings. This is the result of adaptive management relying on the use of linear systems models, discounting non-scientific knowledge and ignoring policy processes that promote understanding among diverse stakeholders. They conclude that to be effective, new adaptive management efforts will need to incorporate knowledge from multiple sources, make use of multiple systems models, and support new forms of cooperation among stakeholders.

While it is apparent that an adaptive management process is necessary for successful ecosystem management, success will ultimately depend upon agencies and organizations capacity and ability to implement ecosystem management initiatives. A common theme identified throughout the literature is organizational change. To implement ecosystem management successfully diverse institutional structures must be changed (Grumbine 1997).

Grumbine (1997) lists three reasons why this is necessary:

1. As general management goals evolve from producing resources to protecting sources, organizations will also be transformed;

2. Bureaucracies are by definition less adaptive to change - that is they are structured not to be responsive to new learning, but to maintain control over resources, information and people;

3. If new ecological theory describes a nature less stable, non-linear, and full of surprise, and if we have constructed managed agencies based on a balanced linear and predictable image of nature, then there is a gap between how we choose to work with nature and the properties of ecosystems. New ecological theory exerts tremendous pressure for change on traditional organizational structures..

Wuichet (1995) provides a discussion on the need for organizational change highlighting an important difference between ecological and bureaucratic systems. He finds that the bureaucratic hierarchy for ecosystem management is not nested like units in natural ecosystems are. As a result, he posits a framework for hierarchical analysis which identifies the scalar units of concern within the framework and traces the line of communication between the units. Through this process the problem of non-nestedness is identified and the need for a panagency ecosystem management policy emerges.

Wuichet (1995), concludes that a "regional policy approach to ecosystem management from the bottom-up is necessary, and is consistent with the system concept of emergent qualities. This approach, however, will need a national, panagenecy policy that provides regional units with enough authority to create effective policies." Therefore both a grass-roots approach and national constraints are necessary if the managerial system is to approach the same temporal and spatial scale of the ecological system its aimed at protecting (Wuichet 1995).

Interagency cooperation is another important theme when discussing ecosystem management. Grumbine (1997) provides a useful discussion regarding what is needed from interagency cooperation. First, all potential partners must share in defining the problem; and second, is the issue of power sharing - unequal power distribution is a major problem. As Westley cited in Grumbine (1997) states "the tendency is toward strong demands for equality from those less powerful and little concern for equality on the part of the powerful." Interagency cooperation is a must, especially in this era of cutbacks, where governments and agencies are being asked to do more with less. A pooling of resources is necessary to increase capacity to fulfill ecosystem management initiatives.

Lastly in the discussion on institutional arrangements, and perhaps most importantly for the long term success of ecosystem management, is the need to change the educational system - i.e. the way ecosystem science and management is taught.

Orth (1995) criticizes the educational system stating that there is to much emphasis placed on teaching specialized skills and professional career training, disciplines are too narrowly defined. This leads to severe specialization, more narrow thinking and research and publications that may

bear little relevance to the needs of society. Another problem Orth (1995) notes is that students receive knowledge from narrowly focused, overspecialized experts - this has implications for being able to solve novel problems. Orth (1995) believes we must move away from a lecture approach wherever possible, as it promotes development of passive students and inhibits critical, creative and imaginative thought. This must be overcome. The reason lecturing persists is because of tradition, ease of adoption, and its link to objective testing (Orth 1995). Ecosystem management must be taught to students from many disciplines simultaneously, where they can grapple with broader ecosystem management goals and uncover the biases inherent in their own disciplines (Orth 1995). For learning to be most effective a balance between lecturing, reading, discussions, labs and simulation models is needed.

6.0 CONCLUDING SECTION

6.1 Summary

The goal of this paper was to identify and analyze a broad range of literature related to ecosystem management.

The goal of section 1 was to trace the development of the ecosystem approach from its infancy to where it is today, as well as the development of ecosystem management; and to provide an objective view of the ecosystem management debate by identifying the key questions and issues with the hopes of building consensus and points of contention, and therefore increasing the understanding of the ecosystem management concept.

The focus of section 2 was on outlining and describing the various components, themes, and principles necessary for successful implementation of ecosystem management initiatives. An analysis of the necessary ecosystem factors and institutional arrangements was presented.

In section 1 the history of the ecosystem approach and of ecosystem management were laid out. This was accomplished by reviewing several papers and books that specifically outlined the history of each to date. The ecosystem management debate was put together by surveying a broad range of articles. The purpose of this chapter was to demonstrate the complexity of the ecosystem management debate by providing an overview of some of the key issues and questions that have emerged from a review of the literature. In reviewing the literature four key questions and issues arose: What is ecosystem management?; Is there a need for a precise definition?; Does ecosystem management represent a paradigm shift?; and the role between the ecological and social sciences in terms of ecosystem management.

It was concluded that there is no precise definition of ecosystem management, and at this stage in the evolution of the concept there will not be

a precise definition formulated. In time there will be a need for a precise definition as this will greatly assist managers and policy makers and everyone involved in ecosystem management. However, as ecosystem management is evolving, it should be left to being defined by its actions for now, until further consensus emerges . That said, it must be acknowledged that ecosystem management be based on the ecosystem approach, an approach based on complex systems theory (Kay and Schneider 1994a). Its principles are based on hierarchy theory, self-organization, chaos and catastrophe theories, non-equilibrium thermodynamics etc. Therefore, ecosystems must be recognized as dynamic, not deterministic, as having a degree of unpredictability, and exhibiting phases of rapid change (Kay and Schneider 1994a). When thought of in this manner ecosystem management does truly represent a paradigm shift in the management of ecological systems. Finally ecosystem science should form the basis of ecosystem management, however the role of the social sciences must be acknowledged as vital to the success of ecosystem management and as a result the role of the social sciences need to be expanded.

Section 2 analyses the necessary ecosystem factors and institutional arrangements necessary if ecosystem management initiatives are to be implemented successfully in the long term. It was concluded that a successful analysis of an ecosystem must consider the following factors and questions when addressing the ecosystem under study:

1. Defining the ecosystem;
2. Describing the ecosystem as a self-organizing entity;
3. Evaluating ecosystem integrity;
4. Is this integrity threatened; and
5. Maintaining ecosystem integrity.

These factors are based on the notions of complex systems theory, hierarchy theory and the process of self-organization.

These ecosystem factors are critical, however, to implement ecosystem management initiatives successfully, the following institutional arrangements must be recognized and become imbedded in the ecosystem management process. These arrangements include the process of adaptive management, where ‘learning by doing’ is essential for ecosystem management. Such a process offers the best opportunity for selecting the best management practice. Organizational change is an institutional arrangement that must be addressed by agencies if ecosystem management is to be effective. A restructuring of the bureaucratic hierarchy must occur so that it matches the appropriate temporal and spatial scale of the ecosystem it is supposed to protect. Interagency cooperation is also a must especially today when managers are being asked to do more with less. Agencies can no longer compete with one another, but instead must pool their resources to become effective and efficient with implementing ecosystem management initiatives.

Finally, changing the way educational systems i.e. universities teach students about ecosystem matters is necessary. A more holistic approach is needed, one that draws on various disciplines simultaneously. In addition the way students are taught needs to be addressed moving away from lecturing whenever possible and incorporating a more diverse learning atmosphere.

6.2 Insights

Completing this paper has demonstrated to me just how complex the task of being an ecosystem manager is. An ecosystem manager must have sound knowledge in a variety of scientific disciplines including ecology, hydrology, biology, chemistry to name just a few, as well as being well educated in social sciences including political science, statistics, sociology and economics. No one can be an expert in all these areas and it is for that reason why the future ecosystem manager must be taught differently and provided with the necessary skills from the various disciplines mentioned above. Even still to think a single person can have all those skills is naïve, ecosystem management initiatives will have to be completed by a team of people having the various backgrounds mentioned above who can work together in an integrated manner. The framework for ecosystem management is emerging, but one that is agreed upon and incorporates all the necessary components is still in the future.

6.3 Recommendations

A precise definition of ecosystem management is needed, but not at this time. Ecosystem management for now must be defined by its actions.

Research into ecosystem science must continue at a more rapid pace to increase understanding and reduce uncertainty surrounding ecosystem science.

The role of the social science must be expanded. Managers must have increased knowledge of socio-economic variables as well as the political process, and how human values come into play with regards to the environment.

Ecosystem management must be based on the ecosystem approach, which is an approach based on complex systems theory; and its principles are based on hierarchy theory, self-organization, chaos and catastrophe theories, and non-equilibrium thermodynamics.

Research must continue on implementing ecosystem management initiatives. Case study analyses must continue to be conducted.

An assessment of the capacity of government agencies is needed. Restructuring of government agencies may be necessary to match the bureaucratic holon to its ecological counter-part.

Universities must restructure the way ecosystem science and management is taught. A program must be established that draws on the various disciplines necessary for successful ecosystem management. Curriculum may have to be altered and even the various departments may have to be reorganized i.e biology, earth sciences etc.

6.4 Project Limitations

All projects of this nature have limitations and can thus be improved. A limitation in this project centers around acquisition of literature. There is a tremendous amount of literature on this topic. I feel I have obtained a vast majority of it, however, I am sure there are important documents, articles, reports and books which I did not uncover.

The Internet was not used as a source of information for this project. Due to time constraints and the nature and scope of this project, this was not possible. Undoubtedly a great deal of information exists on the world wide web.

6.5 Conclusion

Ecosystem management to this day is still evolving and not precisely defined. However it has become the mandated form for managing ecological systems in North America. Ecosystem initiatives are being carried out at an increasing rate, and as a result it is important to understand the complexity surrounding ecosystem management concept. For ecosystem management to be successful it must draw on the emerging knowledge gained from ecosystem science and apply it to the study of ecosystems, but also acknowledge and incorporate the critical importance of the social sciences and its ability to address problems associated with ecosystem management that ecosystem science is not capable of doing. An ecosystem analysis must be completed within the context of an adaptive management process, by an agency that is structured correctly and has the capacity to implement ecosystem initiatives correctly.

7.0 REFERENCES

1. Allen, S. 1997. A SOCIAL SCIENTISTS VIEW OF ECOSYSTEM MANAGEMENT. Journal of Forestry. Sep; 95(9):48.

2. Allen, T. F. H. and Hoekstra, T. W. 1992. TOWARD A UNIFIED ECOLOGY. New York: Columbia University Press;; ISBN: 0-231-06918-9.

3. Alpert, P. 1995. INCARNATING ECOSYSTEM MANAGEMENT. Conservation Biology. Aug; 9 (4):952-955.

4. Bailey, R. G. 1996.MULTI-SCALE ECOSYSTEM ANALYSIS. Environmental Monitoring and Assessment. v39(1-3):21-24.

5. Brunner, R. D. and Clark, T. W. 1997. A PRACTICE-BASED APPROACH TO ECOSYSTEM MANAGEMENT. Conservation Biology. Feb; 11(1):48-58.

6. Carpenter, R. A. 1996. ECOLOGY SHOULD APPLY TO ECOSYSTEM MANAGEMENT - A COMMENT. Ecological Applications. Nov; 6(4):1373-1377.

7. Cooperrider, A. Y. 1996. SCIENCE AS A MODEL FOR ECOSYSTEM MANAGEMENT - PANACEA OR PROBLEM. Ecological Applications . Aug; 6 (3):736-737.

8. Cortner, H.J., Shannon, M.A., Wallace, M.G., Burke, S. and Moote, M.A. 1994. Institutional Barriers and Incentives for Ecosystem Management. Issue Paper Number 16. Tucson: University of Arizona Water Resources Research Center.

9. Czech, B. 1996. ECOSYSTEM MANAGEMENT IS NO PARADIGM SHIFT - LETS TRY CONSERVATION . Journal of Forestry. Feb; 94 (1-6):17-23.

10. Czech, B. and Krausman, P. R. 1997. IMPLICATIONS OF AN ECOSYSTEM MANAGEMENT LITERATURE REVIEW
. Wildlife Society Bulletin. Fall; 25(3):667-675.

11. Fedkiw, J. 1997 THE FOREST SERVICES PATHWAY TOWARD ECOSYSTEM MANAGEMENT. Journal of Forestry. Apr; 95(4):30-34.

12. Fitzsimmons, A. K. 1996. SOUND POLICY OR SMOKE AND MIRRORS - DOES ECOSYSTEM MANAGEMENT MAKE SENSE. Water Resources Bulletin. Apr; 32 (2):217-227.

13. Galindoleal, C. and Bunnell, F. L. 1995. ECOSYSTEM MANAGEMENT - IMPLICATIONS AND OPPORTUNITIES OF A NEW PARADIGM. Forestry Chronicle. Sep-Oct 31; 71(5):601-606.

14. Gerlach, L. P. and Bengston, D. N. 1994. IF ECOSYSTEM MANAGEMENT IS THE SOLUTION, WHAT'S THE PROBLEM? Journal of Forestry . v92 (8):18-21.

15. Gilmore, D. W. 1997. ECOSYSTEM MANAGEMENT - A NEEDS DRIVEN, RESOURCE-USE PHILOSOPHY. Forestry Chronicle. Sep-Oct 31; 73(5):560-564.

16. Golley, F.B. 1993. A History of the Ecosystem Concept in Ecology. New Haven, CT: Yale University Press.

17. Gonzalez, O. J. 1996. FORMULATING AN ECOSYSTEM APPROACH TO ENVIRONMENTAL PROTECTION. Environmental-Management. v20 (5):597-605.

18. Grumbine, R.E. 1992. Ghost Bears: Exploring the Biodiversity Crisis. Island Press, Washington D.C.

19. Grumbine, R. E. 1994. WHAT IS ECOSYSTEM MANAGEMENT? Conservation-Biology. v8 (1):27-38.

20. Grumbine, R. E. 1997. REFLECTIONS ON WHAT IS ECOSYSTEM MANAGEMENT. Conservation Biology. Feb; 11(1):41-47.

21. Haeuber, R. 1996. SETTING THE ENVIRONMENTAL POLICY AGENDA; THE CASE OF ECOSYSTEM MANAGEMENT. Natural-Resources-Journal. v36(1):1-28.

22. Haney, A. and Power, R. L. 1996. ADAPTIVE MANAGEMENT FOR SOUND ECOSYSTEM MANAGEMENT. Environmental Management. Nov-Dec 31; 20(6):879-886.

23. Holling, C. S. 1992 CROSS-SCALE MORPHOLOGY, GEOMETRY, AND DYNAMICS OF ECOSYSTEMS. Ecological Monographs. v62(4):447-502.

24. Holling, C. S. 1986. THE RESILIENCE OF TERRESTRIAL ECOSYSTEMS: LOCAL SURPRISE AND GLOBAL CHANGE. Pages 292-320 in W.M. Clark, and R.E. Munn. (Eds.) Sustainable Development in the Biosphere. Oxford University.

25. Holling, C. S. 1996. SURPRISE FOR SCIENCE, RESILIENCE FOR ECOSYSTEMS, AND INCENTIVES FOR PEOPLE. Ecological Applications. v6(3):733-735.

26. Huff, D. 1995. Ecosystem Management: Panacea or Panic Button? In Sustainable Society and Protected Areas, ed. R. Linn, 93-97. Hancock, MI: The George Wright Society.

27. International Joint Commission. 1994. Ecosystem Charter for the Great Lakes-St.Lawrence Basin. Produced by the Council of Great Lakes Research Managers for the IJC. Draft.

28. Irland, L. C. 1994. GETTING FROM HERE TO THERE: IMPLEMENTING ECOSYSTEM MANAGEMENT ON THE GROUND. Journal-of-Forestry. v92 (8):12-17.

29. Jensen, M. E.; Bourgeron. P.; Everett, R., and Goodman, I. 1996 ECOSYSTEM MANAGEMENT - A LANDSCAPE ECOLOGY PERSPECTIVE. Water Resources Bulletin. Apr; 32 (2):203-216.

30. Kay, J. J. 1991. A NON-EQUILIBRIUM THERMODYNAMIC FRAMEWORK FOR DISCUSSING ECOSYSTEM INTEGRITY . Environmental Management. v15(4):483-495.

31. Kay, J. J. and Schneider, E. 1994a. EMBRACING COMPLEXITY: THE CHALLENGE OF THE ECOSYSTEM APPROACH. Alternatives. v20 (3):32-39.

32. Kay, J.J. and Schneider, E. 1994b. Complexity and Thermodynamics: Towards a New Ecology. Futures Aug. 24 (6) pp. 626-647.

33. Kay, J. 1994a. THE HURON NATURAL AREA: AN ECOSYSTEM APPROACH..www.fes.uwaterloo.ca/u/jjkay/pubs/envmgmt/index.html

34. Kay, J. J. 1994b. THE ECOSYSTEM APPROACH, ECOSYSTEMS AS COMPLEX SYSTEMS AND STATE OF THE ENVIRONMENT REPORTING, prepared for North American Commission for Environmental Cooperation, State of the North American Ecosystem meeting, Montreal, Canada. 8-10 December, 1994, 42 pages.

35. Knight, R. L. 1996. LEOPOLD,ALDO, THE LAND ETHIC, AND ECOSYSTEM MANAGEMENT. Journal of Wildlife Management. Jul; 60(3):471-474.

36. Knight, R. L. and Meffe, G. K. 1997. ECOSYSTEM MANAGEMENT - AGENCY LIBERATION FROM COMMAND AND CONTROL. Wildlife Society Bulletin. Fall; 25(3):676-678.

37. Lee, K.N. 1993. Compass and Gyroscope: Integrating Science and Politics for the Environment. Island Press, Covelo, CA.

38. Marcin, T. C. 1995. INTEGRATING SOCIAL SCIENCES INTO FOREST ECOSYSTEM MANAGEMENT RESEARCH. Journal of Forestry. Nov; 93 (11):29-33.

39. McLain, R. J. and Lee, R. G. 1996. ADAPTIVE MANAGEMENT: PROMISES AND PITFALLS. Environmental Management. v20(4):437-448.

40. More, T. A. 1996. FORESTRY'S FUZZY CONCEPTS: AN EXAMINATION OF ECOSYSTEM MANAGEMENT. Journal-of-Forestry. v94 (8):19-23.

41. Orth, D. J. 1995. Pogo Was Right! LET'S CHANGE THE WAY WE TEACH FISHERIES MANAGEMENT. FISHERIES. v20(9):10-13.

42. Pahl-Wostl, C. 1995 The Dynamic Nature of Ecosystems. Chaos and Order Entwined. Chichester, Toronto: Wiley.

43. Salwasser, H. 1994. ECOSYSTEM MANAGEMENT CAN IT SUSTAIN DIVERSITY AND PRODUCTIVITY. Journal of Forestry. Aug:6(10).

44. Tarver, C. M. 1995. ECOSYSTEM MANAGEMENT - GIVING IT MEANING. Journal of Forestry. Jan; 93(1):60.

45. Taylor, W. W.; Ferreri, C. P.; Poston, F. L., and Robertson, J. M. 1995. EDUCATING FISHERIES PROFESSIONALS USING A WATERSHED APPROACH TO EMPHASIZE THE ECOSYSTEM PARADIGM. Fisheries. v20(9):6-9.

46. Ulanowicz, R.E. 1997. Ecology, The Ascendant Perspective. New York: Chichester, England: Columbia University Press.

47. Wenger, K. F. 1997. WHAT IS ECOSYSTEM MANAGEMENT. Journal of Forestry. Apr; 95(4):44.

48. Wilcove, D. S. and Blair, R. B. 1995. THE ECOSYSTEM MANAGEMENT BANDWAGON. Trends in Ecology & Evolution. Aug; 10(8):345.

49. Wrona, F. 1994. Ecosystem Science - Now and in the Future. Backgrounder for Science and Technology Review. National Hydrology Research Institute, Saskatoon, Saskatchewan.

50. Wuichet, J. W. 1995. TOWARD AN ECOSYSTEM MANAGEMENT POLICY GROUNDED IN HIERARCHY THEORY. Ecosystem-Health . v1 (3):161-169.