University of Alberta

Interdisciplinarity in Ecosystem Management

by

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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Earth and Atmospheric Sciences

Fall 2010
Edmonton, Alberta

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Dedication

To Pablo, Maia and little Tau

The three of you made this possible. Pablo, you have always been by my side, supportive and patient. Maia, you have always been reminding me of what is truly important in life. Tau, you have made me realize once again the magic of life.

Gràcies. Us estimo molt.

Abstract

Global environmental deterioration demands the involvement of the academic community. Ecosystem management is a discipline within ecology that is especially concerned about doing interdisciplinary research in order to solve environmental problems. However, it is not clear what interdisciplinary work means, what its purpose is, and how it is practiced among ecosystem management researchers. The research presented in this dissertation has the goal of understanding ecosystem management researchers' perspectives and practices concerning interdisciplinarity. It uses a pragmatic framework and a sequential mixed-methods research design to accomplish three particular objectives. First, it investigates the use of the term interdisciplinarity in the ecosystem management literature by evaluating citations and abstracts of 129 peer-reviewed, English language, journal articles via bibliometric analysis. Second, it explores the definition of interdisciplinarity among ecosystem management researchers by surveying 119 individuals using on-line questionnaires. Finally, it examines interdisciplinary perspectives among ecosystem management researchers by interviewing 15 key informants using semi-structured telephone interviews. Results show that ecosystem management researchers share a common understanding of what interdisciplinarity is. However, they are not especially concerned about discussing theoretical considerations of the concept of interdisciplinarity and its practice. In the context of the opportunities and challenges interdisciplinary work presents for the ecosystem management field, the research discusses the role of a deeper engagement with theories of

interdisciplinarity. It encourages theoretical discussions of interdisciplinary work among ecosystem management researchers in order to enhance effective interdisciplinary research efforts and promote further contributions of ecosystem management to solving environmental problems.

Acknowledgement

I am most grateful to my academic advisors for their ongoing support. To my supervisor, Dr. Theresa Garvin, I really admire your infinite patience through this process. I thank you for your invaluable direction and the faith in me. To Dr. Rick Szostak, I am particularly thankful for your always positive and constructive feedback. Your support helped keep me on the right path and in good spirits. To Dr. Bob Summers, thank you for your thought provoking discussions.

I was also lucky enough to have the support and friendship of other graduate students, professors, and other staff in the Department of Earth and Atmospheric Sciences. Blythe, Chuck, Esther, Amy, Sharon, Brian, Kurt, Bob, Matt, Carlos, Ewa, Michael, Igor, Kim, Marsha, and Carmen, thank you! Outside the university, in the 'real world', I have to thank my wonderful friends Robe, Fer, Lila, Alicia, Susan, Hilary, Amira, Jeremy, Esther, and Natalie, thanks!

I must also deeply thank all the participants who contributed to this study. Your willingness to share your perspectives made this project possible. I am especially grateful to those participants who besides contributing their views, also showed particular interest in the work and gave me cheerful comments about it.

I would like to acknowledge with thanks the financial support I received from the Mexican National Science and Technology Council (CONACYT, Doctoral scholarship #205603/228694), the Killam Research Fund, University of Alberta, and the logistical support from the Community, Health and Environment Research Centre, at the University of Alberta.

Finally, I must once again deeply thank my family. Pablo, Maia and Tau, thank you so much. I also thank the rest of my family, who from very far away, and never really understanding what I was doing, were always supportive. Marta, I hope you get better very soon; ànims!

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CHAPTER 1

INTRODUCTION

1.1. Introduction

Environmental deterioration represents a serious threat to societies (Likens, 1991; Noss & Cooperrider, 1994). Society as a whole, and more specifically the scientific community, have responsibility for reversing and preventing this situation (Gibbons, 1999; Kates et al., 2001; Clark & Dickson, 2003). Ecosystem management (EM) is a field within ecology that addresses environmental problems by supporting and promoting interdisciplinary practice. Interdisciplinarity offers EM researchers valuable opportunities to contribute to solving environmental deterioration (Norton, 1992; Costanza, et al., 1993; Gunderson et al., 1995; Blockstein, 1999; Berkes et al., 2003). At the same time, however, it represents important challenges for research practice (Heberlein, 1988; Naiman, 1999; Wear, 1999; Jakobsen et al., 2004; Lele & Norgaard, 2005; Keough & Blahna, 2006).

The overarching goal of the research presented in this dissertation is to understand EM researchers' perspectives and practices concerning interdisciplinarity. In the context of the opportunities and challenges interdisciplinary work presents for the EM field, the research attempts to develop theoretical considerations about interdisciplinary activity. It seeks to encourage theoretical discussions among EM researchers in order to enhance effective interdisciplinary research efforts and promote future contributions to environmental problems.

Specific objectives of the research are:

1) To investigate the use of the term interdisciplinarity in the EM literature during the last four decades, and detect patterns in it.
2) To explore the definition of interdisciplinarity among EM researchers.
3) To examine interdisciplinary practice among EM researchers.

1.2. Methodology

The study presented here uses a pragmatist research approach to explore how interdisciplinary work is understood and practiced by researchers in the EM field. The pragmatist approach guides research by focusing on the research problem. It is not committed to any one system of philosophy about reality and the research process. It thus, opens the door to different assumptions and multiple forms of data collection and analysis (Cherryholmes, 1992; Creswell, 2007).

The study uses a mixed-method research design. It includes instruments and procedures traditionally employed in both quantitative and qualitative research (Creswell, 2003; Tashakkori & Teddlie, 2003). Quantitative research creates generalizations of an objective reality and requires significant attention to the measurement of the phenomena studied (Patton, 2002; Neuman, 2003).

Quantitative methods are therefore adequate to detect patterns in the use of the term interdisciplinarity in the EM literature (Objective 1), and to investigate the definition of interdisciplinarity among EM researchers (Objective 2). Qualitative research stresses the socially constructed nature of reality, and attempts to secure depth and detailed understanding of the phenomena studied (Lincoln & Guba, 1985; Denzin & Lincoln, 2000; Maxwell, 2005). Qualitative methods are therefore suitable to explore in-depth understandings of interdisciplinarity (Objective 2), and to examine how EM researchers experience and give a meaning to interdisciplinary practice (Objective 3).

1.3. Structure of the dissertation

This dissertation is structured around the three particular objectives of the research project (see Figure 1-1 for an overview of the research project). It contains six chapters. The present is the first chapter (*Chapter 1. Introduction*). It introduces the work by establishing research objectives, research methodology, and structure of the dissertation. The following chapter (*Chapter 2. Background*) provides the research context. It sets the basis for the subsequent chapters by presenting the concepts of interdisciplinarity and EM as well as their corresponding academic fields: interdisciplinary research and EM research. Chapters 3, 4 and 5 are the substantive chapters of the dissertation. They were conducted sequentially, and are presented as independent entities, with their own methods, results, discussion, and conclusions. Each chapter addresses one of the particular research objectives, informs and introduces the following objectives, and supplements previous objectives. A version of each chapter has already been published in academic journals or is in the process of being submitted for publication[1].

Chapter 3 (*Literature Evaluation*) fulfils Objective 1 by investigating the use of the term interdisciplinarity in the EM literature. Specifically, it presents the results of a bibliometric analysis of citations and abstracts of 129 international, peer-reviewed, English language journal articles published between 1970 and 2008. This chapter reveals that a minority of EM works both mention interdisciplinary research and engage with theories of interdisciplinary research. This chapter opens discussion about how EM researchers include interdisciplinary work in their research, and the current role of theoretical considerations about interdisciplinary activity in the EM field.

Chapter 4 (*Questionnaire Survey*) fulfils Objective 2 by making explicit the meaning of interdisciplinary work among a set of EM researchers. It presents the results of an online close-ended questionnaire that surveyed 119 researchers who are first, second or corresponding authors of the works used on the bibliometric analysis conducted in Chapter 3. Results indicate researchers differ on the terminology used for interdisciplinary research; however, they share a common

[1] A version of Chapter 3 has been already published in *The International Journal of Science in Society*. Versions of Chapters 3 and 4 are in preparation to be submitted for publication in *Science, Technology and Human Values*, and *Conservation Biology* respectively.

understanding of what interdisciplinarity is. Findings situate EM in the broader context of interdisciplinarity in science, and promote further discussions about the concept in EM and its contributions to advancing EM research.

Chapter 5 (*Interview Study*) fulfils Objective 3 by examining the process of doing interdisciplinary work in the EM field. This component of the project used semi-structured telephone interviews to conduct an in-depth evaluation of 15 active EM researchers. Results suggest that discussions about interdisciplinary practice are not part of EM's mainstream research activity, and when such discussions are present they do not include explicit and detailed descriptions of the interdisciplinary process. This chapter concludes by identifying those theoretical discussions that do take place within EM as well as those occurring outside the field, and encourages a dialectical engagement between EM researchers and those outside of EM studying theories of interdisciplinarity.

Finally, *Chapter 6* (*Conclusion*) synthesizes the previous chapters and identifies relationships between them. It outlines the major contributions of the research, discusses research limitations and introduces areas for future work.

1.4. Figures

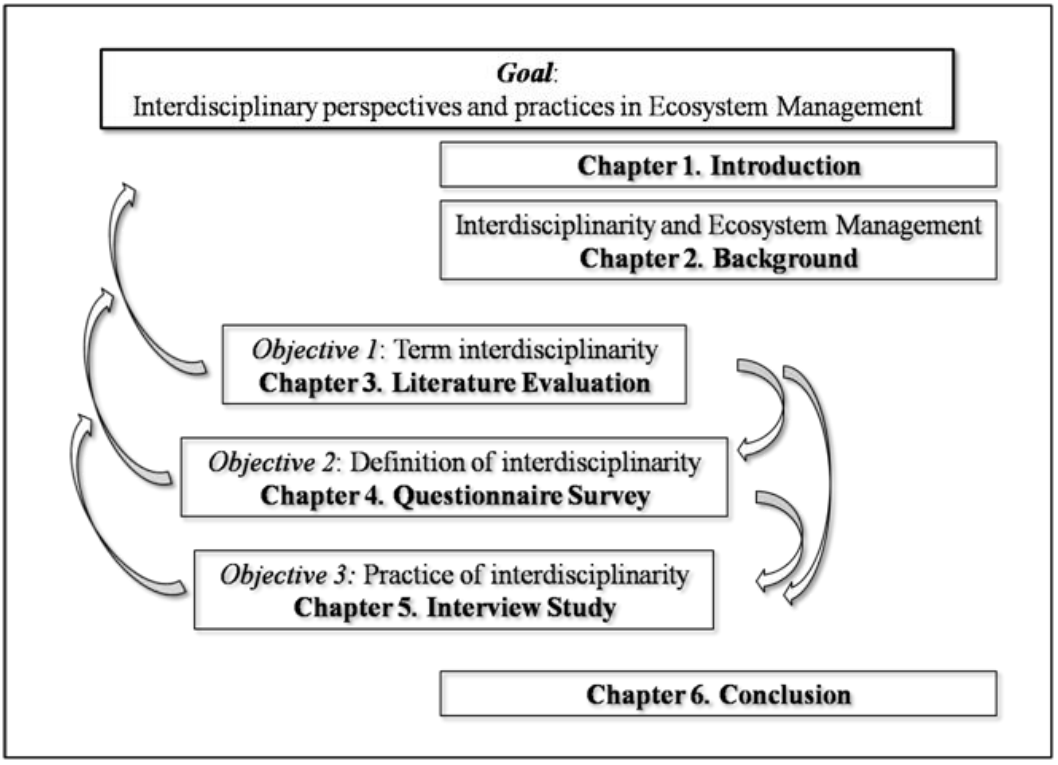

Figure 1-1. Overview of the research project

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CHAPTER 2

BACKGROUND: INTERDISCIPLINARY AND ECOSYSTEM MANAGEMENT RESEARCH

This chapter provides an overview of two concepts central to the work presented in this dissertation: interdisciplinarity, and ecosystem management (EM). These concepts are the central focus of two separate academic fields: interdisciplinary (or integrative) research, and EM research. The clarification of the meaning of the two concepts and the presentations of the main points discussed in the two fields constitute the basis for developing and contextualizing this research project.

2.1. Interdisciplinary research

2.1.1. Introduction

The term interdisciplinarity refers to the process of producing, teaching and learning scientific information that involves the integration of the insights of more than one discipline or field of study (Klein, 1990). The present work focuses exclusively on interdisciplinary research and uses the expression ‘interdisciplinary research’ (or ‘interdisciplinary work’) to refer to interdisciplinarity. Although ‘interdisciplinarity’ is equivalent to ‘interdisciplinary research’, the work does not prioritize the term ‘interdisciplinarity’. It is mainly used by experts on the theory of interdisciplinary research, but scientists specialized in the different disciplines are not generally familiar with it.

The expression interdisciplinary research has seen increased use in the academic literature of various fields in recent years. Fields such as biotechnology, molecular biology, risk assessment and technology assessment focus on broad issues and demand an interdisciplinary approach (Gibbons et al., 1994). In these disciplines, interdisciplinary research has become somewhat of a buzzword as specialized researchers recognize the need for collaboration. Despite the increased profile of interdisciplinary efforts in research, the meaning of interdisciplinary research, its purpose and its practical applications have rarely been studied in great detail (Moran, 2002; MacMynowski, 2007). In separate areas of study such as integrative (or interdisciplinary) studies experts have been trying to deal with such issues about interdisciplinary research (Chubin et al., 1986; Klein, 2000; Repko, 2008). These theoretical discussions of interdisciplinary research can help specialized scientists to become more self-aware about interdisciplinary work and thus more effective in undertaking it.

The aim of the following sections is to present the meaning of interdisciplinary research in the way that it is increasingly agreed on by experts on the theory of interdisciplinary research. As the concept of interdisciplinary work is based on the concept of discipline, the nature of disciplines must first be discussed. Since

disciplines and interdisciplinary work are the result of the evolution of academia, an overview of the origins and evolution of disciplines and interdisciplinary research are also presented.

2.1.2. The concept of discipline

Interdisciplinary research is generally (although not always) defined as a research process that implies the integration of the insights from more than one discipline. Therefore, the idea of interdisciplinary research is possible only in a disciplinary world, and the concept of discipline is crucial for the concept of interdisciplinary research.

Discipline is a concept commonly defined as a field of study (or area of academic research practice) characterized by a body of accepted knowledge related to a well-defined subject, established on the basis of generally accepted principles (Kockelmans, 1979; Swanson, 1979; Klein, 1990; Klein, 1996; Salter & Hearn, 1996; Szostak, 2003; Repko, 2008). Disciplines can be identified by communities of scholars working in these fields (Apostel, 1972; Heckhausen, 1972; Becher & Trowler, 2001; Lattuca, 2001). Communities of scholars have institutional recognition in the form of departmental divisions at universities, graduate programs, academic journals, conferences, and scholarly associations (Turner, 2000; Brew, 2001; Ratnam, 2004).

Many scholars in their effort to define discipline list the points that characterize a particular discipline and make it different from other disciplines (see for example: Heckhausen, 1972; Petrie, 1976; Swanson, 1979). The works of Klein (1990 and 1996), Salter & Hearn (1996), Szostak (2003), and Repko (2008) synthesize these characteristics in five interrelated elements:

1. **Phenomena**. Every discipline has a series of subjects or topics of interest in a certain subject area that are addressed by scholars in the discipline. Biology, for example, is focused on the study of life, and within this broad research interest biologists address particular issues such as structure, growth, reproduction, and metabolism of living organisms.

2. **(Evolving) theories.** Every discipline (at a certain moment in time) has a coherent group of general conceptual prepositions such as laws, models, and concepts that are widely accepted by researchers in the discipline. These conceptual prepositions are explanations about some aspect of the world, how it works, and why specific facts are related. Theories are supported by research, and at the same time are essential to conduct research. In biology, an example of theory is evolution. Biologists, in their attempts to contribute to the discipline use evolutionary theory to explain most of the issues they study involving living organisms.

3. **Methods**. Disciplines have a set of accepted research instruments (or tools) and modes of inquiry (or procedures or techniques) to conduct

research. Methods determine the way a scientist gathers evidence, transforms evidence into data, analyses data, uses data to test theories, and produces new knowledge from data (Barnes, 1985; Brew, 2001; Repko, 2008). Some disciplines are open to many different methods, and others are restricted to very specific ones. Some methods such as descriptive and inferential statistics, experiments, questionnaires, or mathematical models are highly generalized across disciplines. Other methods such as systematic review or electronic microscopy are more specific to certain disciplines.

4. **Rules**. Every discipline has a set of normative guidelines that dictate how to pursue 'proper' research. They are criteria for validity and reliability of the research process. They allow researchers to understand, evaluate, and build upon each other's work (Szostak, 2002). Rules of a discipline are consistent with phenomena, theories, and perspectives of that one discipline. But rules are also affected by the institutional organization in the academy. Departmental divisions at universities, academic journals' tendencies, funding agencies' policies, promotion criteria, and scholarly societies' trends influence what is to be rewarded within every discipline (Salter & Hearn, 1996; Brew, 2001; Ratnam, 2004). Traditions and quality standards for publishing research are examples of rules. They differ across disciplines, especially when considering the social and natural sciences (Zuckerman & Merton, 1971; Wanner et al., 1981; Martinko et al., 2000).

5. **Perspectives**. The perspectives of a discipline are the set of agreed upon assumptions that frame the production of knowledge in that discipline. They both reflect and influence a discipline's choice of phenomena, theories, methods, and the existence of particular rules. Perspectives articulate the different disciplinary elements (Szostak, 2003). They define, for example how reality is perceived and how to produce knowledge about it, what constitutes an interesting and appropriate question to study, and what a convincing answer to the question should look like (Newell, 2007). To provide an example of different perspectives we contrast the approach of biology and sociology to study human societies and their interactions with the environment. Biologists view the world as constituted by living interacting organisms in a physical world. They tend to study the social world looking at the deterministic explanations of subjects as exposed to forces and laws of nature, without considering the decision-making capacity of individuals. Sociologists view the world as socially constructed by people that live in it. They tend to study the natural world looking at the understandings of individuals and social groups about the natural world and the decisions of interacting with it without much emphasis on natural or physical restrictions to such decisions.

In summary, disciplines are areas where academic research is carried out. Researchers in each discipline address particular phenomena using a specific set

of theories, methods, and rules under certain disciplinary perspectives to create disciplinary insights. Insights are specific arguments about the nature of a phenomenon, or about how a phenomenon influences other phenomena. They represent a cognitive advancement about the phenomena studied, and are, therefore, the basis for its understanding (Szostak, 2003; Repko, 2008). As a result, disciplines can be conceptualized as intellectual entities for research practice whose 'boundaries' or 'domains' are defined by particular phenomena, theories, methods, rules and perspectives (Klein, 1996).

It is important to emphasize that the definition of discipline presented here does not imply that disciplines are static and well-defined intellectual entities. Disciplines are products of social structures. They attract individuals interested in similar phenomena and committed to certain theories, methods, rules and perspectives. Individuals are influenced by social-cultural reality, and this social-cultural reality evolves historically (Heckhausen, 1972; Swoboda, 1979; Turner, 2000; Brew, 2001; Ratnam, 2004). As a result, disciplines are evolving and diffuse units that are in part arbitrarily delimited.

Disciplines are evolving units. As part of the process of knowledge growth, disciplines interact and evolve (Klein, 1993; Klein, 1996). Within disciplines, new lines of inquiry are defined to create subdisciplines (or specialities). Subdisciplines can eventually evolve to new disciplines. Examples of subdisciplines evolving to new disciplines are botany, ecology, and physiology in biology; or economic history, social history, and political history in history (Klein, 1996). At the same time, disciplines and subdisciplines may be recombined and create hybrids (also called interdisciplines), such as Latin-American studies, women's studies, environmental studies, or urban studies (Klein, 1996). Hybrids can eventually become new disciplines. Commonly recognized cases of this evolution are bioethics, geoecology, ecological economics, nanotechnology, and biochemistry, among others (Kockelmans, 1979; Swoboda, 1979; Klein, 1993; Klein, 1996; Salter & Hearn, 1996; Repko, 2008).

Disciplines are diffuse units. Disciplines overlap with other disciplines and at the same time are heterogeneous entities. On the one hand, the elements that define a discipline (i.e. phenomena, theories, methods, rules, and perspectives) are not exclusive of that discipline; they are points of commonality between that discipline and other disciplines (Salter & Hearn, 1996). The disciplines biology and veterinary medicine can represent an example. They are traditionally considered different disciplines, but in broad terms both of them study life, use evolutionary theory and a positivistic quantitative perspective. On the other hand, phenomena, theories, methods, rules, and perspectives that characterize a discipline are not homogeneous within this discipline (Apostel, 1972; Campbell, 1986; Klein, 1996; Salter & Hearn, 1996). Researchers within a discipline do not completely agree on what theories or methods to use. Within certain limits, individual researchers may differ in their preferences and still publish in journals or be hired in institutions related to a particular discipline. Moreover, disciplines

are constituted by subdisciplines, which are in turn defined by particular phenomena, theories, methods, rules, and perspectives. Ecology for example is constituted (among many other subfields) by: population ecology, which studies the dynamics of populations of a single species; ecophysiology, which focuses on the physiological functions of organisms that influence the way they interact with the environment; and, political ecology, which connects politics and economics to environmental problems. The particular principles that guide research in these three subfields are not the same.

Disciplines are not absolute units. The described evolution of disciplines, the overlap between disciplines, and the heterogeneity inside the disciplines imply that disciplinary boundaries cannot be unquestionably delimited (Klein, 1993; Klein, 1996; Ratnam, 2004). This situation might result in disagreements on considering for example ecology or genetics as disciplines by their own, or subdisciplines of the discipline biology. It can also lead to the debate about why political ecologists are generally considered to belong to ecology together with population ecologists, and to be separated from political economists, who belong to economics or political sciences. Political economists and political ecologists probably share more phenomena, theories, methods, rules and perspectives than do political ecologists and population ecologists. They are probably related to the same or similar scholarly journals, academic meetings, and university departments. They can therefore be considered equivalent or close disciplines.

This questionable boundary definition between disciplines may suggest that the definition of discipline lacks any value. However, such definition is still appropriate as it brings clarity to the concept of interdisciplinary research. The concept of discipline exposed here does not give a definite answer as to what counts as discipline. It does not provide a clear answer to whether ecology and botany are to be considered disciplines by themselves or subdisciplines of biology, or whether environmental studies and biotechnology are to be considered hybrids or disciplines. It neither helps to decide whether a project where two or more ecologists (e.g. ecophysiologists and population ecologists) are working together can be considered an interdisciplinary study, or whether a project integrated by political ecologists and political economists (i.e. ecologists and economists or political scientists) can be considered an interdisciplinary study. However, the concept of discipline provided here entails the sense that there are communities of scholars who tend to study particular subjects in a shared manner, and that people expert in these different manners (interdisciplinary individuals or interdisciplinary teams) can create knowledge beyond any one discipline.

2.1.3. The concept of interdisciplinary research

Interdisciplinary research is not easy to define. After two decades of a rich and diverse debate over what it means, a group of experts on the theory of interdisciplinary research have reached consensus (Newell, 2001; Newell, 2007; Repko, 2008). Repko (2008:12) presents this agreed definition of interdisciplinary research as:

> "A process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline and draws on disciplinary perspectives and integrates their insights to produce a more comprehensive understanding or cognitive advancement."

This definition puts together the three main questions related to the sense of the term: what interdisciplinary research is; when it is used; and, why is it used. Following these questions we can deconstruct the definition into the following statements:

1) Interdisciplinary research is a process of answering a question, solving a problem, or addressing a topic, that integrates disciplinary insights of more than one single discipline.
2) Interdisciplinary research is used when the question, problem or topic to be addressed is broad or complex.
3) Interdisciplinary research is used to produce a more comprehensive understanding of the complex or broad question, problem or topic to be studied.

The following sections will present the meaning of interdisciplinary research by commenting on these three statements.

2.1.3.1. Interdisciplinary research is a research process of integration

According to the first statement about Repko's (2008) definition, interdisciplinary research is a process of answering a question, solving a problem, or addressing a topic, where insights of two or more disciplines are integrated. From this sentence we can conclude two things. The first one is that interdisciplinary research is a research process. It seeks to answer a question, solve a problem, or address a topic, which are the purposes of research (Barnes, 1985; Brew, 2001; Ratnam, 2004). Interdisciplinary research is then a research procedure or strategy, rather than a particular instrument or tool for doing research (Repko, 2008). The second conclusion is that in the interdisciplinary research process different disciplines participate and the disciplinary insights they create are integrated. The main views presented in the literature about interdisciplinary research as a research process and interdisciplinary research as a process for integration are indicated in the two following sections.

2.1.3.1.1. Research process

Different disciplines understand and practice research in different ways. The phenomena studied, and the theories, methods, rules, and perspectives used to study these phenomena differ from one discipline to another. Based on these five elements, Szostak (2004) proposes a classification of research. He differentiates various 'kinds of research' according to who is doing the research, what the researcher is investigating, why the research is investigating it, and how the researcher is doing the study. In a similar way, experts on the theory of interdisciplinary research differentiate between kinds of interdisciplinary research according to the topic the researcher is addressing, the researcher's motivations,

and the levels and ways of interaction between disciplines the researcher uses (Klein, 1990). Using these criteria together we can identify two broad kinds of interdisciplinary research (Klein, 1996; Salter & Hearn, 1996; Lattuca, 2001). These include:

- instrumental interdisciplinary research, and
- conceptual interdisciplinary research

Instrumental interdisciplinary research and conceptual interdisciplinary research have their own groups of proponents who define interdisciplinary work in two different ways (Klein & Newell, 1997).

Proponents of instrumental interdisciplinary research belong mostly to the natural and applied sciences, but can also belong to the social sciences and even the humanities (Lattuca, 2001). They define interdisciplinary research as the process leading to integration of the insights from two or more disciplines in order to develop a practical solution to an unsolved problem. Instrumental researchers attempt to create synthesis of disciplinary insights that helps addressing the needs dictated by the specific problem at hand. Interdisciplinary work is then a means and not an end in itself (Klein, 1990; Klein, 1996; Salter & Hearn, 1996; Lattuca, 2001). Within this perspective, the complementarity of disciplinary and interdisciplinary work is crucial. On the one hand disciplinary insights are integrated to create interdisciplinary understanding that contributes to the solution to a problem. On the other hand, the resulting interdisciplinary insights can suggest new ideas and research questions to disciplines for conducting further research.

For the most part, proponents of conceptual interdisciplinary research belong to the social sciences and especially the humanities (Lattuca, 2001). In contrast to proponents of instrumental interdisciplinary research, they tend to relate interdisciplinary research to a critique of the disciplinary structure of knowledge (Klein, 1996; Salter & Hearn, 1996; Lattuca, 2001). In contrast to instrumental interdisciplinary research, conceptual interdisciplinary research is an end in itself. Some proponents of conceptual interdisciplinary research define interdisciplinary work as the process promoting integration of the insights of two or more disciplines for creating an overarching synthesis of knowledge that transcends disciplinary boundaries (Lattuca, 2001; Moran, 2002). It is traditionally referred to as transdisciplinary research[2] (Kockelmans, 1979; Swanson, 1979; Salter & Hearn, 1996; Klein, 1996; Kockelmans, 1998; Lattuca, 2001). Results of transdisciplinary efforts are, for example, theories such as the second law of thermodynamics, energy-mass equivalence, general systems theory, information

[2] More recently transdisciplinarity research has taken on different meanings. Sometimes it means interdisciplinary research that includes people from beyond the academy, as it is the case of the European transdisciplinary movement (Hirsch Hadorn, 2008). Sometimes just means interdisciplinary research as pursued by a group of scholars mostly based in Europe (Szostak, 2007).

theory, and game theory; and overarching perspectives such as Marxist or structuralism research approaches which are universal across disciplines. Other proponents of conceptual interdisciplinary research (normally for feminist and postmodernist approaches), define interdisciplinary work as the process for dismantling disciplines, not maintaining or integrating them (Lattuca, 2001; Szostak, 2007)

2.1.3.1.2. Integration

As indicated above, interdisciplinary research is a process leading to integration of disciplinary insights. Researchers (especially those proponents of instrumental interdisciplinary research) agree that integration is a key concept of interdisciplinary work. However, integration is a concept usually defined in broad and ambiguous ways such as any form of dialogue, interaction, linkage or bridging between disciplines (Klein, 2000; Moran, 2002). Before the 1990s, experts on theory of interdisciplinary research rarely focused on integration (Klein, 1990). Since the 1970s they were generally centered on distinguishing 'levels of integration' through hierarchical typologies of interdisciplinary research that reflected different ways of linking disciplines (with terms such as multidisciplinary, pluridisciplinary, interdisciplinary, and transdisciplinary research; see for example various chapters of Apostel et al., 1972).

By the end of the 1990s and beginnings of 2000s, Klein (1996), Szostak (2002), and Newell (2001 and 2007) bypassed discussions about levels of integration and started a deeper discussion about what integration means and entails. According to these authors, integration is the process of combining disciplinary insights (Repko, 2008). In this process, disciplinary insights that make more relevant contributions to understanding the phenomena are considered (Szostak, 2002). Methods, theories, rules and perspectives that generated relevant insights are gradually put together and modified, creating common methods, theories, rules and perspectives. Common disciplinary elements are then used as the basis to create interdisciplinary (integrated) insights about the phenomenon studied (Newell, 2001; Szostak, 2002; Szostak, 2003; Szostak, 2007; Repko, 2008). Interdisciplinary insights are "something altogether new, distinctive, apart from, and beyond the limits of any discipline" (Repko 2008: 6). They are the basis for understanding the phenomenon studied and then the key for answering the question, solving the problem or addressing the topic that motivated the research effort.

2.1.3.2. Interdisciplinary research addresses breadth and complexity

Repko (2008) in his definition states that the 'breadth' and 'complexity' of the problem, question or topic to be addressed are what motivate interdisciplinary work. Breadth refers to the study of an issue that cuts across the boundaries of two or more disciplines (Klein, 1990; Klein, 1993; Repko, 2008). Complexity refers to the study of an issue that is constituted by several parts that are interrelated by

non-linear processes[3] (Repko, 2008; Newell, 2001). Both breadth and complexity mean that no discipline is traditionally focused on studying a problem, question or topic comprehensively. Many disciplines within their own domains can offer disciplinary insights on it, but it cannot be appropriately addressed by any discipline. An example of it is the origins of bioengineering, before being constituted as a discipline on its own. Before the 1970s, current bioengineering issues were mainly between the boundaries of genetics and engineering. Both disciplines were able to provide disciplinary insights to these issues, but none of them could give a complete answer to it. The participation of biology, climatology, and geography (for example) in addressing environmental problems might provide another example. The mentioned disciplines are interested in the topic and have the theories, methods, rules and perspectives to address it. However, integrating insights from them might provide information that helps understand the topic in a different, and maybe more complete, way than any of them alone would do.

As described, breadth and complexity of the phenomena under study demand the participation of more than a single discipline. However, the fact that more than one discipline is required does not mean there is a need for integration. Disciplinary insights might just need to be added to provide an adequate understanding of the phenomenon. A particular study, for example, might focus on the perception of people about environmental deterioration. The mere contribution of survey methods from social sciences' disciplines, and particular statistical methods form natural sciences' disciplines might suit the objective of the study. Cases such as the one described, where inputs of the disciplines simply complement each other and disciplinary insights are only juxtaposed, are generally called multidisciplinary (or pluri- or crossdisciplinary), as opposed to interdisciplinary (Klein, 1990; Newell, 2001; Finkenthal, 2008).

2.1.3.3. Interdisciplinary research produces a more comprehensive understanding

Repko (2008) states that interdisciplinary research produces a more comprehensive understanding of the issue, than a disciplinary and multidisciplinary research (i.e. juxtaposition of insights) would do. The question to be answered, the problem to be solved or the topic to be addressed could not be tackled satisfactorily under a single disciplinary or multidisciplinary approach.

In interdisciplinary research insights produced in different disciplines are combined to generate new and integrated insights. As these insights are the product of integration they cannot be reduced to the separate disciplinary insights from which they emerged (Newell, 2001). In consequence, by definition, integrated insights represent a more complete knowledge about the issue studied

[3] Complexity here is used in the broad sense. However, narrower definitions of the concept have been proposed to explain the rationale for doing interdisciplinary research. See for example the debate initiated by Newell (2001).

than disciplinary insights do. As a result, interdisciplinary research triggers a more comprehensive understanding about the issue studied than a disciplinary or multidisciplinary effort would do.

2.1.4. The history of disciplines and interdisciplinary research

Disciplines have their precedents in the first modern university: the medieval university. The medieval university was created in Europe in the $12^{th} – 13^{th}$ century (Lindberg, 2007). It evolved from much older cathedral schools and monasteries to become permanent institutions that moved away from the old abstract learning to prepare students for the professions and to serve direct social needs (Swoboda, 1979; Klein, 1990; Moran, 2002; Lindberg, 2007). By the 13^{th} century universities were teaching a series of courses that included both the arts and the sciences. After being taught in this core curriculum students went on to specialize in the faculties of medicine, law or theology (Swoboda, 1979; Lindberg, 2007).

During the European Renaissance ($14^{th} – 17^{th}$ centuries) and the educational reform of the Reformation (16^{th} century) universities were consolidated as educational and training institutes (Swoboda, 1979). Specializations were ordered under faculties of medicine, law and theology, which taught and trained students under very rigid, formalized and hierarchical structures (Salter & Hearn, 1996). Research activities took place outside the context of universities. People from different backgrounds interested in research joined scientific societies to develop inquiry in certain fields. During the 16^{th} and 17^{th} centuries scientific societies evolved to a new institution, the scientific academy (Swoboda, 1979; Barnes, 1985).

During the late 17^{th} and 18^{th} centuries the production of knowledge and disciplinary specialization accelerated with the European intellectual movement of the Enlightenment. Enlightenment thought placed great emphasis on the progress of human knowledge through the powers of rationality, which was supported by the development of clearer procedures and methodologies within disciplines, and greater specialization of learning (Henry, 2008). The Enlightenment's trend to specialization overlapped with and drew on the rise of modern science with the scientific revolution occurring in the 16^{th} and 17^{th} centuries (Moran, 2002; Repko, 2008). The scientific revolution was based on the view of nature as a well-ordered machine that could be explained by rules discovered by humans, and on the development of an empirical method to test hypotheses about particular aspects of the natural world (Henry, 2008).

With these intellectual changes, in the 18^{th} century the medieval university was replaced by a new model of university, the German university model, which integrated the scientific academy and the university (Swoboda, 1979). Under the German model, universities produced specialized knowledge and trained students in these fields of specialization. Students were trained for success in professional life and to return to the university as academic staff. As part of this trend to

specialization, universities established disciplinary departments, and the scientific community created more professional scientific associations and professional journals (Barnes, 1985; Repko, 2008). At this point, we see the genesis of the concept of academic disciplines as known today (Lattuca, 2001).

In the 19th century as a result of the industrial revolution and technological advances, universities were expected to respond to social needs. The industrial marketplace imposed specific demands, which resulted in further specialization in the disciplines (Salter & Hearn, 1996). The disciplinary structure of the natural sciences responded to industrial and technological demands, and the disciplinary structure of the social sciences to government and industry demands for research in policy formulation, administration and population growth measurements (Salter & Hearn, 1996).

For the first half of the 20th century universities were constituted by academic units according to disciplines. Schools, faculties and departments controlled and constrained knowledge production. The combination of social and institutional bureaucratization resulted from demands for efficient specialized professionals, which in their turn resulted in a greater disciplinary specialization (Klein, 1996). Disciplines were working in relative isolation from each other. As a response to their limited contribution to current broad and complex problems, the need for interdisciplinary research was made evident (Klein, 1996).

The history of interdisciplinary research according to Klein (1990) started with a period dated between 1918 until 1930, between the two World Wars. In this period, discussions about interdisciplinary research were part of a broader movement toward educational reform. In response to the increasing fragmentation of knowledge within the educational system, cohesiveness has sought through the arts and values associated with classical humanism that integrated knowledge across disciplines (Klein, 1990; Repko, 2008).

Klein (1990) and Repko (2008) discuss a second period of interdisciplinary research after the Second World War through to 1970. Instrumental interdisciplinary research was highly encouraged for military and political ends. Government funded research laboratories and institutes to develop interdisciplinary projects and encouraged their progress (Klein, 2000). In particular, physics and engineering were protagonists of big interdisciplinary projects such as the Manhattan Project. In the 1960s, student protests encouraged conceptual interdisciplinary research. The discipline-based structure of knowledge and its power in regulating social relations and obscuring the true understanding of what were important issues of the day were highly criticized and contested (Repko, 2008).

The third period of interdisciplinary research started in the 1970s and continues to the present (Chubin et al., 1986; Klein, 1990; Klein, 2000). It is the period that Weingart & Stehr (2000) call the ‘postdisciplinary stage’. Government continued

supporting instrumental interdisciplinary research, but this time favouring the link between industry and the academy. New programs, centres, and activities proliferated. During this period, the natural sciences were still the main protagonists. However, the preference for areas of defence, aerospace and industry shifted by the 1970s to product safety, environmental quality, technology assessment, and information systems (Klein, 2000; Lattuca, 2001; Repko, 2008). The social sciences were gradually included in interdisciplinary efforts although they were still playing a secondary role (Lattuca, 2001).

Besides the important practice of interdisciplinary work through applied projects, these last decades are also characterized by the study of interdisciplinary research. Since the 1970s the number of academic associations, educational institutions, international conferences, and publications discussing interdisciplinary work has been increasing (Chubin et al., 1986). By mid-1980s there were experts on the theory of interdisciplinary research leading theoretical discussions about interdisciplinary work (Klein, 2000; Repko, 2008).

As a result of practical and theoretical research done in interdisciplinary work, nowadays, the importance of interdisciplinary efforts has already been established. On one side, collaborations among disciplines are becoming more common and accepted. The complementary nature of disciplinarity and interdisciplinary work is shaping a new way of doing research to face real problems that transcend individual disciplines. And on the other side, interdisciplinary research is studied in its theoretical domain and has been gaining agreement on what it is and what it entails.

2.2. Ecosystem Management research

2.2.1. Introduction

EM is a particular area of academic research or field of study within the broader field of ecology. It addresses the interaction between societies and nature, and contributes to the maintenance of natural systems[4] over the long term. Often researchers use the term EM to allude to the process of managing nature in the face of human activity. This refers to actions humans perform to use goods (e.g. food, timber, fuels, pharmaceutical) and services (e.g. recycling, cleansing, recreation, or spiritual inspiration) from natural systems (Daily, 1997), and actions they undertake to conserve and restore natural systems for future use. In the present work we use EM to speak of the process of doing research about the management of nature. We, nevertheless, acknowledge that both the process of managing nature and the process of practicing research about the management of nature are intertwined as part of the adaptive management approach.

[4] In the present work to avoid confusion between terminology we use the term ‘natural system’ to refer exclusively to the natural dimension of ecosystems, the term ‘social system’ to refer exclusively to the social dimension of ecosystems, and the term ‘ecosystem’ or ‘socio-ecological system’ (Berkes et al., 2003; Gallopin et al., 1989) to refer to the whole system integrated by the social and ecological dimensions.

The literature in EM is wide, rich and diverse (Grumbine, 1994b; Lackey, 1998; Yaffee, 1999). EM is a field still in development, and there is ongoing debate about what EM is and entails (Haeuber, 1996). The purpose of the following sections is to present the field of EM as generally agreed by EM researchers. It introduces the ecological foundations of EM, the main points that define the field, and the academic antecedents and socio-political context that promoted its creation and establishment as a management framework.

2.2.2. Ecological foundations

EM emerged in ecology as a result of important changes in ecological theory during the 1980s (Pickett & Ostfeld, 1995). Ecologists in this period saw that the traditional (i.e. earlier) way of addressing natural systems oversimplified and idealized the natural world. Theories, methods, perspectives and rules traditionally used to advance knowledge about nature were gradually abandoned and replaced by new ones. This change of paradigm (Kuhn, 1996) was based on the recognition of dynamism or flux of nature over equilibrium or balance of nature. The incorporation of the idea of complexity in how nature is explained becomes central. At this point, ecosystems (or 'socio-ecological systems') started being defined as functional units. These functional units were composed of a set of social and ecological elements (such as persons, families, communities in the social domain; and genes, species, populations in the natural domain) and processes (including economic incomes or knowledge interchanges in the social domain, and migration and pollution fluxes in the natural domain). Processes were functional relationships established between the elements that are based on exchanges of energy, matter and information. Thanks to these functional relationships, the elements interact with each other and work in concert as a unit. Ecosystems are units in constant change in space and time, and have uncertain and at best only quasi-predictable behaviour (Odum, 1992; Norton, 1992; Costanza et al., 1993; Gunderson et al., 1995; Berkes et al., 2003).

The new idea of nature as complex systems was explained in the context of the transition from an 'equilibrium paradigm' to a 'non-equilibrium paradigm' based on six interrelated dualities (Holling, 1978; Worster, 1985; Real et al., 1991; Botkin, 1992; Pickett & Ostfeld, 1995; Jørgensen, 2007):

1. **Closed / open systems**. Under the equilibrium paradigm natural systems were seen as closed systems. Although researchers did recognize energy and physical constraints from the outside, natural systems were considered to be structurally complete (referring to composition of organisms) and functionally complete (referring to the processes of interaction between organisms and between organisms and non-living elements). In the non-equilibrium paradigm, ecologists consider natural systems to be open entities, characterized by inputs and outputs of energy (e.g. light, heat), matter (e.g. organisms (migration), nutrients, pollution), and information (e.g. genetic and physiologic information).

2. **Self-regulating / non self-regulating systems**. In the equilibrium paradigm, as a consequence of defining natural systems as closed, they were also defined as self-regulating. That is, natural systems regulate their own performance. They never get too far off-balance and can bring themselves back to their equilibrium status. In the non-equilibrium paradigm, natural systems are considered to be regulated by events occurring inside and outside their boundaries. The structure and functioning of natural systems are determined by energy, material and information internal interchanges, and inputs and outputs.

3. **Single stable points of equilibrium / multiple persistent states**. According to the equilibrium paradigm, natural systems had single stable points of equilibrium. Stable points of equilibrium define states where the system goes back after a perturbation and remain until a new perturbation occurs. According to the non-equilibrium paradigm, although stable points of equilibrium may on odd occasions be found, systems have multiple persistent states. Perturbations are part of the systems' dynamics and result in new points of (temporary) equilibrium. The existence of multiple points of equilibrium defines natural systems as dynamic, flexible, and thus, with an uncertain and quasi-predictable behaviour.

4. **Fixed / rarely fixed succession**. The ecological succession (or change in composition of communities) was perceived as fixed under the equilibrium paradigm. That means that communities, since they are established on a site until they mature, followed a trajectory that always passed through the same phases. In the final phase (called 'climax') communities presumably remained stable for long periods of time. Disturbances were viewed as events that push succession back to earlier stages. Under the non-equilibrium paradigm, the composition of communities is not understood as guided by a predetermined pathway. Natural events such as predation, diseases, and natural or human perturbations influence the physiological traits and behaviours of the different organisms. Therefore, they influence the future composition of communities. A final maturity state is not often to be found.

5. **Undisturbed / disturbed systems**. Under the equilibrium paradigm, disturbances (such as fires, windstorms, floods, or droughts) were considered to be exceptional events. Under the non-equilibrium paradigm disturbances are considered part of the systems' dynamics. They affect the systems' structure and functioning. When a system is disturbed, it can be transformed into a new system.

6. **Separate from / integrated by humans**. In the equilibrium paradigm natural systems were seen as exclusively integrated by natural components and processes. Humans and social processes were considered external

factors of disturbance that can violate some of the principals already listed. In the non-equilibrium paradigm, humans become an integral part of the systems. They influence and are influenced by the systems' dynamics.

2.2.3. The field of Ecosystem Management

EM is a field still at an early stage of development (di Castri & Hadley, 1985; Haeuber, 1996; Van Kerkhoff, 2005). The EM literature does not present a unique definition of EM. The concept still means slightly different things to different people (Stanley, 1995; Fitzsimmons, 1996; Yaffee, 1999; Meffe et al., 2002; Dekker et al., 2007). The definition that is the most cited in the literature is the one proposed by Grumbine (1994b: 31), which states:

> "EM integrates scientific knowledge of ecological relationships within a complex socio-political and values framework toward the general goal of protecting native ecosystem integrity over the long term."

In a general and comprehensive sentence Grumbine (1994b) defines EM as a research field that has the goal of contributing to nature's well-being, emphasizing the importance of taking into account both the natural and social dimensions of ecosystems (what he ambiguously calls 'scientific knowledge' and 'socio-political and values framework' respectively).

Among the variety of definitions used in the literature there are several recurring themes that describe EM (Slocombe, 1993b; Grumbine, 1994b; Christensen et al., 1996; Haeuber, 1996; Franklin, 1997; Lackey, 1998). Expressed as statements these five themes describe EM as follows:

1) EM adopts a systemic perspective
2) EM pursues sustainability
3) EM involves collaborative research
4) EM entails interdisciplinary work
5) EM is part of an adaptive management process

The five statements are interrelated and as a group explain the concept of EM. It is through commenting individually on the five statements and showing the main researchers' points of debate that we will present the field of EM.

Although it is not the objective of the present sections, it should be noted that together with the definitional debate presented here, EM researchers debate how EM is and should be practiced. The implementation of all five points introduced in the following sections is highly challenging and has not been completely solved. For further debate on the practice of EM, see for example: Gray, 1989; Wood, 1994; Christensen et al., 1996; Yaffee, 1996; Yaffee et al., 1996; Yaffee, 1999; Slocombe, 1998; Pavlikakis & Tsihrintzis, 2000; Wondolleck & Yaffee, 2000; Butler & Koontz, 2005.

2.2.3.1. Ecosystem Management adopts a systemic perspective

For most researchers the term 'ecosystem' in the expression 'ecosystem management' stands for a metaphor implying systems thinking (Agee & Johnson,

1988; Knight & Bates, 1995; Slocombe, 1993a; Slocombe, 1998; Yaffee, 1999; Meffe et al., 2002). It means that a particular management issue can only be effectively addressed if a system-wide, holistic, integrative view of the issue is considered.

Even if the particular management problem studied is related to certain elements or processes of the ecosystem it is crucial to recognize that these elements are fundamentally interconnected by exchanges of energy, matter and information between them and with the other components of the system. All the components of the system work as a functional whole in continuous dynamism. Given this on-going change some researchers discuss the geographical and temporal limits that should be imposed when defining the system. Often the conclusion is that strict limits are in fact irrelevant (Pavlikakis & Tsihrintzis, 2000; Meffe et al., 2002). The actual spatio-temporal scale of the study is to be determined by the needs of the particular management issue to be addressed, and should be large enough to encompass the relevant elements and linkages among elements in the system (Agee & Johnson, 1988; Noss & Cooperrider, 1994). To restore a stream, for example, the adequate geographical scale might be the area of a watershed, where components such as water, organisms, human communities, and processes like biochemical cycles, interactions among organisms or between humans and water, are included. However, a watershed might not necessarily be an adequate unit of study to control an agricultural pest in a field or to design a strategy for the extraction of medicinal plants by a particular human community. For the time scale, in a similar way, to address a plague of locusts it might be preferable to include short-term ecological and social processes. To deal with global climate change it might be relevant to include long-term natural processes and short-term social processes that consider the timelines of government and policy decision-makers.

2.2.3.2. Ecosystem Management pursues sustainability

In a broad sense, all researchers agree that EM has the long-term goal of sustainability, which is defined as the guarantee of future provision of goods and services from nature (Lubchenco et al., 1991; Keystone Center, 1996; Christensen et al., 1996). EM thus, focuses on the social goal of obtaining benefits from nature, and the natural goal of achieving well-being of natural systems.

Despite the broad agreement on this definition and considering it the focus of EM, not everybody agrees it is possible to balance both social and natural goals (Grumbine, 1994b; Callicott, 2000). Some suggest that it is impossible because we cannot ‘maximize’ more than one factor at a time (Stanley, 1995). In the middle of this debate, there is a group of people who argue that EM’s primary focus is the protection of nature. They advocate for: protection of ecological integrity and ecosystem health (Angermeier & Karr, 1994; Grumbine, 1994b), prevention of ecological degradation (Noss & Cooperrider, 1994), safeguarding of ecological sustainability (Wood, 1994), or maintenance of structural complexity and biological diversity (Christensen et al., 1996; Keystone Center, 1996). By protecting nature and assuring its long-term maintenance, researchers argue

societies in the future will be able to enjoy the goods and services nature provides. According to this view, social benefits from nature are secondary to natural systems' well-being. Social needs and demands must be accommodated to natural constraints and cannot always be fulfilled (Noss & Cooperrider, 1994; Stanley, 1995; Grumbine, 1997). Alternatively, there is another group of researchers who see human needs as equally important or more important than the well-being of natural systems. Although they recognize that societies depend on nature to satisfy needs, and that there are ecological constraints on social demands, they acknowledge the importance of managing nature according to the social requirements of goods and services (Agee & Johnson, 1988; Kessler et al., 1992; Wood, 1994; Zeide, 1998; Cortner & Moote, 1999).

2.2.3.3. Ecosystem Management involves collaborative research

Researchers in the EM field widely recognize the importance of collaboration of various social actors in research (Gray, 1989; Lee, 1993; Cortner & Moote, 1999; Meffe et al., 2002; Keough & Blahna, 2006; Wallerstein & Duran, 2008). They acknowledge the limitations of scientific research to understand and guide human actions (Funtowicz & Ravetz, 1994; Gibbons et al., 1994; Kates et al., 2001; Clark, 2002; Berkes et al., 2003). The mismatch between knowledge production capacities in academia and social knowledge requests is overcome with the involvement in the research process of non-academic actors such as landowners, government agencies, managers, NGOs and other populations involved or interested in management (Cortner & Moote, 1999; Gray et al., 2001; Meffe et al., 2002).

Academics and non-academics try to reconcile their often contrasting perspectives using collaborative approaches. In a mutual and continuous learning process they make joint decisions about the research (Lee, 1993; Brunner & Clark, 1997; Westley & Miller, 2003; Keen et al., 2005). They interact to define a management problem of common interest, to conduct the research, and to apply the research results and solve the problem (di Castri & Hadley, 1985; Gray, 1989; Lee, 1993; Tress et al., 2004; Keough & Blahna, 2006; Hirsch Hadorn, 2008). Non-academic actors contribute lay, local and traditional knowledge about the institutional machinery in which environmental decisions are applied, their particular understanding of ecosystems, and their own values, needs, preferences, and expectations about ecosystems (Gray et al., 2001; Clark, 2002; Meffe et al., 2002; Keough & Blahna, 2006). Academics provide expert scientific disciplinary knowledge about ecosystems (e.g. biodiversity data, thresholds for minimum acceptable ecosystem conditions, human population densities, policy processes), and the disciplinary knowledge produced from the information provided by non-academics (di Castri & Hadley, 1985; Clark & Dickson, 2003; Steel et al., 2004; Hanssen et al., 2009).

Although the recognition of the need for interaction between academics' and non-academics' knowledge is widely recognized, there is a debate on the relative importance of academic and non-academic contributions to EM. Some researchers argue that information set by scientific experts must prevail over information

from non-academics (Grumbine, 1994b; Noss & Cooperrider, 1994; Christensen et al., 1996; Lackey, 1998). In contrast, other researchers emphasize the importance of non-academic information, recognizing the role of local and traditional knowledge (Lee, 1993; Gunderson et al., 1995; Cortner & Moote, 1999; Wondolleck & Yaffee, 2000). They consider that the input of society in general and especially those of farmers, fisherman and other natural resource managers can define the success of an EM project to a large extent (Agee & Johnson, 1988; Kessler et al., 1992; Meffe et al., 2002).

2.2.3.4. Ecosystem Management entails interdisciplinary work

The need to integrate insights from social fields such as sociology or political science, and natural fields such as ecology or geography to address the concerns of environment is widely acknowledged (Heberlein, 1988; Wilson, 1998; Blockstein, 1999; Daily & Ehrlich, 1999; Naiman, 1999; Redman, 1999; Pickett et al., 1999; Wear, 1999; Nyhus et al., 2002; Eigenbrode et al., 2007). The involvement of single disciplines provides only partial views of complex socio-ecological systems. Therefore, it does not necessarily adequately tackle the issues studied (Klein, 1990; Bailis, 2001; Newell, 2001; Szostak, 2003; Repko, 2008).

Despite the recognized value of interdisciplinary research in EM, current debates in the literature suggest researchers generally prioritize the involvement of similar disciplines, especially those in the natural sciences. Debates indicate that the participation of the social sciences in EM is traditionally pushed into the background, and often simply used to make natural sciences more accessible to governments, the public, and markets (Endter-Wada et al., 1998; Cormier-Salem, 1999; Pickett et al., 1999; Lowe et al., 2009).

2.2.3.5. Ecosystem Management is part of an adaptive management process

EM scientists generally define EM as a research process intertwined with the application of the research in management actions under the adaptive management approach (Christensen et al., 1996). Since ecosystems are open, dynamic and flexible systems, and therefore, uncertain and quasi-predictable (Gunderson et al., 1995; Berkes et al., 2003), any knowledge about ecosystems will always be provisional and incomplete. There is no way to have knowledge about ecosystems that can ensure an adequate management. The best way to deal with uncertainty and quasi-predictability is managing adaptively (Holling, 1978; Lee, 1993; Walters, 2001).

Adaptive management helps to improve the quality of the information used to make managerial decisions through a process of learning-by-doing. It formulates management actions as continuous experiments that probe the responses of ecosystems when people acquire knowledge about the ecosystem and when they interact with it by implementing the experiments' results. The implementation of the results promotes a learning process that allows designing further experiments enabling more effective managerial actions (Lee, 1999).

2.2.4. The history of Ecosystem Management

EM was originated by scientists in the United States as an alternative to the traditional approach to resource management. This traditional approach was highly utilitarian, based on short-term yield and economic gain. It had devastating consequences on the environment (Knight & Bates, 1995). In the decades of the 1970s and 1980s, as an answer to environmental deterioration, together with key advances in ecological theory, ecologists gradually developed the EM field. Important changes in American society and the political context ensured that EM progressed from the scientific community to the political and social spheres.

2.2.4.1. Academic antecedents

The first academic antecedent of EM is the traditional (or utilitarian) resource management approach. Later antecedents were attempts to repair the unsuccessful results of the traditional approach by establishing management in ecosystem-level concerns. Of particular importance are the works of a few early visionary ecologists such as Aldo Leopold (Callicott, 2000).

2.2.4.1.1. The traditional resource management approach

The traditional resource management approach was originated in the United States at the beginning of the 20th century by American researchers trained in Europe in natural resource management disciplines, especially forestry (Knight & Bates, 1995). Researchers saw that natural goods such as forests, fisheries, and grasslands in their country were being overexploited and advocated for the protection of nature (Knight & Meffe, 1997; Meffe et al., 2002). The scheme of protection they proposed was based on the continuous manipulation of natural systems. The goal was to improve and sustain maximum levels of extraction of resources, while still allowing natural systems to continue producing and ensuring opportunities for future exploitation.

The traditional management scheme entailed the active involvement of scientific experts. The scientific basis of the traditional approach to management is parallel to what has been discussed above as the equilibrium paradigm in ecology (Pickett et al., 1992; Pickett & Ostfeld, 1995; Meffe et al., 2002). Natural systems were seen as closed, self-regulating, orderly, in a steady state and with single equilibrium points. The internal dynamics of the system were assumed to adjust to any manipulation. Any change such as the extraction of organisms, introduction of species, or alteration of physical conditions, would not prevent the system from returning to its balance[5]. Technological ingenuity was used to control certain events and obtain a specific outcome (resource extraction, for example) without disturbing the predetermined pathway towards the climax community. Natural and human disturbances were considered external events and therefore, excluded from management strategies. Human activities different to those related to expert

[5] Examples of extraction of organisms include timber extraction, or removal of predators to favor certain species. Examples of introduction of species include grazing for cattle, or offsite growing species becoming extinct and reintroducing them into nature. Examples of alteration of physical conditions include pest control using pesticides.

interventions were seen as threatening to natural systems. For promoting conservation of nature and the recuperation of exploited extensions of nature, particular areas were isolated from perturbation and designed for preservation. Preservation measures such as the establishment of protected natural areas were expected to bring natural systems themselves to the desired (pristine) state and to maintain themselves in that state.

2.2.4.1.2. Ecological antecedents

In the late 1930s, Aldo Leopold (1887-1948) proposed an alternative perspective to the traditional approach: what he called "the land ethic." Leopold's perspective was based on the understanding of nature not as a collection of parts, but as an integrated system composed of interdependent components and processes, all which were relevant to the functioning of the entire system. Leopold was thus already implying that ecosystems were systemic (functional) units. He also stressed that conservation could no longer be defined in preservationist terms. Humans interact with nature and have to be considered part of the disturbances affecting the systems' dynamics. By introducing the scientific concepts of ecological integrity (i.e. natural systems as one complete unit; Norton, 1992) and ecological health (i.e. functionality of natural systems; Costanza et al., 1992) he conciliated conservation and use of natural systems. Leopold established the grounds to reshape ecology's theoretical assumptions into what later would be the non-equilibrium paradigm (Callicott, 2000).

Besides Leopold, there are other pioneers of the ideas basic to ecology and conservation. One example is Shelford (with works like the 1933 report of the Ecological Society of America's Committee for the Study of Plant and Animal Communities). He recognized the importance of considering ecological (functional) units when establishing natural areas for protection, and the importance of interagency cooperation and social participation in protection efforts (Grumbine, 1994b). Other examples are Wright, Dixon and Thompson (with works like Wright & Thompson, 1935). They warned about the possible unsuccessful results of the United States' national parks' system since it did not include complete ecological units (Shafer, 2001).

During the 1970s and 1980s a number of biologists focused their attention on different aspects of what now is known as the EM approach. In 1988 the first book presenting the theoretical framework of EM was published (Agee & Johnson, 1988). Since then, the academic literature discussing and supporting EM has been growing. The adoption of the EM approach in the American political sphere during the 1990s represents a major boost for promoting EM. During the following two decades scientists in the United States and all over the world have been increasingly interested in implementing EM (Wood, 1994; Yaffee, 1996; Slocombe, 1998), and advancing its theoretical development (Franklin, 1997; Lackey, 1998; Yaffee, 1999).

2.2.4.2. Socio-political context

The early political and social backgrounds for the success of EM beyond academic grounds can be traced back to the pioneer period in the United States. The 18th and 19th centuries were marked by an unfettered exploitation of natural resources. The United States had lots of land with important natural resources to be used. Settlers coming from densely populated Europe to realize their dreams of a better life saw the new lands as an unlimited source of resources to be exploited (Knight & Bates, 1995; Cortner & Moote, 1999). The federal government facilitated the establishment of newcomers in private farms and established uncontrolled opportunities for resource development (Cortner & Moote, 1999; Ewert et al., 2004). However, the myth that natural resources were inexhaustible gradually eroded while the concern for preservation and conservation grew. Some early naturalists of the 19th century such as Henry David Thoreau (1817-1862) and John Muir (1838-1914) cautioned the public and the government about overexploitation. Instead, they promoted the preservation of large areas in a pristine state (Knight & Bates, 1995; Cortner & Moote, 1999; Meffe et al., 2002; Bonnicksen & Burton, 2003).

Also responding to environmental claims, but from a contrasting perspective, researchers in natural resource disciplines proposed the already mentioned traditional resource management approach. Since the progressive era was highly supportive of science and technology the traditional approach was well received in the political arena (Knight & Bates, 1995; Cortner & Moote, 1999; Wondolleck & Yaffee, 2000). The main promoter of this perspective was the forester Gifford Pinchot (1865-1946), who managed to make the traditional approach a government priority. He created the United States Department of Agriculture - Forest Service (in 1905) to manage public forests and grasslands (Bonnicksen & Burton, 2003). By the late 1930s this support to the traditional approach was extended to many other land management agencies. The traditional approach became institutionalized as the management approach for rivers, agricultural soils, rangelands, sport and commercial fisheries, game animals, and scenic areas (Flader, 1994; Cordell & Bergstrom, 1999; Wondolleck & Yaffee, 2000; Butler & Koontz, 2005).

The government's support for the traditional approach to the custody of public lands was maintained through the Second World War. After the war, the federal government could no longer support it for a number of reasons, including industrialization and technology breakthroughs, economic expansion, population growth, and migration of people to suburbs. These led to an overwhelming social demand for public resources that exceeded the government's capacity to administer (Knight & Bates, 1995; Meffe et al., 2002; Ewert et al., 2004). At the same time, social values were no longer compatible with the utilitarian political approach to management. Prosperity made it possible for people to spend more of their leisure time in the forests. As a result, society started demanding that public lands become recreational spaces (Bonnicksen & Burton, 2003). The environmental crisis was evident, and as people became increasingly aware of the

consequences of industrialization, they demanded better environmental quality (Wondolleck & Yaffee, 2000; Meffe et al., 2002; Ewert et al., 2004). Simultaneously, people became more involved in political issues. In the United States, general public resentment at the actions of its government in events such as the Cold War, the wars in Korea and Vietnam, and the Watergate scandal resulted in people insisting that their voices had to be included in policy decisions. There was no place for a top-down, government-mandated scheme of management (Grumbine, 1994a; Bonnicksen & Burton, 2003).

As a consequence of these social changes, in the 1980s, the government progressively accepted the EM approach that was then being developed by ecologists. The adaptive, decentralized, bottom-up, cooperative way of understanding management embodied in EM was more congruent with the social values and needs of those days. During the early 1990s, EM was pushed to be the new model guiding public land management policies in the United States based on the concept of sustainability (Yaffee et al., 1996; Malone, 2000). Government, non-governmental organizations, professional societies (e.g. the Ecological Society of America), and groups of managers (e.g. the Wildlife Society), collaborated in the effort of adopting the concept, exploring its theory, and applying it to management practice (Haeuber, 1996). Although increasingly prevalent in the United States, EM efforts have also been pursued in countries such as Canada, Australia, the Netherlands, France, Germany, Greece and Turkey (Pavlikakis & Tsihrintzis, 2000; Ozesmi & Ozesmi, 2003; Dekker et al., 2007).

Some authors claim that EM is losing popularity in recent years as a framework for public and private management decisions (Yaffee, 1999). However, there is a growing body of literature that reports and discusses EM theory and practice, which indicates that the field is still gaining supporters (Yaffee, 1999; Pavlikakis & Tsihrintzis, 2000; Berkes et al., 2003; Dekker et al., 2007).

2.3. Conclusions

Interdisciplinary and EM research are two separate academic fields tied together in the research presented in this dissertation. Interdisciplinary research focuses on studying the process of integrating insights from disciplines to answer a question, solve a problem or address a topic that is too broad or complex to be dealt with appropriately by a single discipline. EM focuses on studying the interaction between societies and nature to contribute to the maintenance of natural systems over the long term. EM entails an interdisciplinary research approach.

By introducing the concepts of interdisciplinary work and EM, as well as the main points of the current debate in the fields of interdisciplinary and EM research, this chapter presented the research context. It set the basis for developing the subsequent chapters of the dissertation, which discuss EM researchers' perspectives and practices concerning interdisciplinary work.

2.4. References

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CHAPTER 3

PATTERNS IN THE USE OF THE TERM INTERDISCIPLINARITY A LITERATURE EVALUATION[6]

3.1. Introduction

The relationship that human societies have established with natural systems has given rise to regional, continental, and global environmental deterioration that represents a serious threat to societies (Likens, 1991; Noss & Cooperrider, 1994). Scientists have become increasingly involved in shaping solutions to environmental problems over the last several decades (Kates et al., 2001; Clark & Dickson, 2003). Ecology in particular has been recognized as a discipline that can make important contributions to the use and conservation of natural systems (Lubchenco et al., 1991; Christensen et al., 1996; Cordell & Bergstrom, 1999; Gallopin et al., 2001).

Situated within the broader field of ecology, Ecosystem Management (EM) is particularly promising for preventing and reversing environmental deterioration (Grumbine, 1994; Pickett & Ostfeld, 1995; Christensen et al., 1996). EM examines the social and ecological processes that contribute to the maintenance of the ecosystem structure and function over the long term (Grumbine, 1994; Christensen et al., 1996; Yaffee, 1999). It is recognized as emerging in the United States in the 1980s as a response to three concurrent developments: unsuccessful results coming from the traditional approach to natural resource management; social and political demands for solutions to environmental deterioration; and, scientific advances in studying ecosystems (Pickett et al., 1992; Pickett & Ostfeld, 1995; Knight & Bates, 1995; Cortner & Moote, 1999; Callicott, 2000). EM combines the systemic (holistic) ecosystem-based management approach (Slocombe, 1993), the collaborative research perspective (Gray, 1989; Keough & Blahna, 2006), and the adaptive management approach (Holling, 1978; Lee, 1993; Walters, 2001). EM researchers generally recognize both the importance of incorporating humans as interacting elements of ecosystems (Noss & Cooperrider, 1994; Grumbine, 1994; Christensen et al., 1996), as well as the relevance of integrating social and natural scientific knowledge for understanding ecosystems (Heberlein, 1988; Wilson, 1998; Endter-Wada et al., 1998; Pickett et al., 1999; Thornhill, 2003, Lowe et al., 2009). Since EM research requires insights from different disciplines such as biology, sociology and politics to advance knowledge, it is defined as engaging interdisciplinary research. Interdisciplinary research is a process leading to integration of the insights from more than one discipline that helps answer a question, solve a problem, or address a topic that is

[6] A version of this chapter has been published. Pujadas Botey, A., & Garvin, T. (2010). Interdisciplinary research in ecosystem management. A literature evaluation. The International Journal of Science in Society, 1(4), 185-213.

too broad to be dealt with adequately by a single discipline (Klein, 1990; Salter & Hearn, 1996; Klein & Newell, 1997; Szostak, 2003; Newell, 2007; Repko, 2008).

In EM, and in the broader field of environmental research as a whole, scientists from diverse disciplines often collaborate (e.g. Quon et al., 2001; Antle et al., 2001; Campbell, 2003; Boyd et al., 2006; Mietton et al., 2007; Lavorel et al., 2007), and integrate different fields of study (e.g. Wondolleck & Yaffee, 2000; Meffe et al., 2002; Berkes et al., 2003; Pennington, 2008). In effect, much work in the EM literature supports and promotes interdisciplinary research. However, within EM there are few theoretical discussions regarding interdisciplinary research efforts. While some EM studies identify interdisciplinary research barriers and challenges (Heberlein, 1988; Redclift, 1998; Daily & Ehrlich, 1999; Pickett et al., 1999; Naiman, 1999; Golde & Gallagher, 1999; Wear, 1999; Mascia et al., 2003; Jakobsen et al., 2004; Campbell, 2005; Lele & Norgaard, 2005), and others propose strategies and tools for overcoming the main obstacles (Janssen & Goldsworthy, 1996; Clark, 1999; Heemskerk et al., 2003; Keough & Blahna, 2006; Eigenbrode et al., 2007), most of these discussions are usually kept at the level of practice. Very little work in EM engages with more recent developments and literatures examining theories of interdisciplinary research (TID) (MacMynowski, 2007).

Despite the fact that EM is inherently interdisciplinary and many authors have commented on the challenges of interdisciplinary research, there is little evidence of an interest in studying how researchers in the field think of interdisciplinary research or how they try to pursue interdisciplinary work. The purpose of this chapter is to take the first step in bringing together EM with broader theoretical discussions about interdisciplinary research currently taking place outside the EM literature. Specifically, its goal is to evaluate (via bibliometric analysis) a set of works published in international, peer-reviewed, English language journals to find patterns in the use of the term ‘interdisciplinary’ in EM literature. Findings will generate discussions about how EM researchers might include interdisciplinary work in their research. It will also contribute to future in-depth discussions of how to generate dialectical engagement between EM researchers and those studying TID.

3.2. Methods

Stage One of the literature evaluation consisted of a bibliometric search of English language, peer-reviewed, academic research citations and abstracts in the EM literature that refer to interdisciplinary research by employing the term ‘interdisciplinary’ or closely related terms (‘multi-’, ‘cross-‘ or ‘transdisciplinary’) in citation information. Stage Two consisted of the analysis of the set of citations and abstracts. It used descriptive statistics and correspondence analysis.

3.2.1. Stage One: Data collection and selection

Figure 3-1 presents the search strategy used to collect citations and abstracts in the EM literature via keywords searches in electronic academic journal databases

(Berelson, 1952; Mackay, 2007). The search sought out papers that contain the keyword ‘ecosystem management’ and the keyword ‘interdisciplinary’ (for interdisciplinary research) or other possible expressions for it, in title, abstract, and keywords (Cooper & Ribble, 1989) in bibliometric records. Nine key electronic databases were employed: Academic Search Complete, BIOSIS Previews, CAB Abstracts, Compendex (Engineering Index), Ecology Abstracts, Geography, ProQuest Science Journals, Scopus, and Web of Science. Papers included were published in international, peer-reviewed, English language journals (Wear, 1999) between 1970 and 2008. Works with incomplete citation information, as well as those missing abstracts, were excluded from the study. The search resulted in 139 papers. Title, keywords and abstract of papers resulting from the search were submitted to evaluation by the principal investigator and four additional researchers (two natural scientists and two social scientists) to exclude works not related to EM. The final set included citation information and abstracts from 129 works.

3.2.2. Stage Two: Data analysis

3.2.2.1. Descriptive statistics

The group of 129 works were described according to both general and interdisciplinary characteristics. Table 3-1 presents variables that explain general characteristics of the works such as number of authors, geographic location of corresponding author, or publication period. Table 3-2 identifies variables that indicate interdisciplinary characteristics such as the term used to refer to interdisciplinary research, where in the citation the term is used, and whether or not the abstract indicated that the work engaged with TID. These variables explain how the authors of the works included in the study refer to interdisciplinary research.

Based on the information provided in the title, keywords and abstract, the papers were reviewed and assigned a category per variable (see Tables 3-1 and 3-2). Most categories (those corresponding to the variables: number of authors, continent, year, journal name, terminology, and location) were directly assigned from the information provided by the databases. When categorization involved subjectivity (variables: type of journal, keywords classification, and objective), a double-blind test was employed to ensure reliability and validity (Glaser & Strauss, 1967; Kassarjian, 1977; Neuman, 2003). The principal investigator and four affiliated researchers (two natural scientists and two social scientists) assigned categories separately until achieving a minimum of 80% agreement (Budd et al., 1967; Neuman, 2003).

3.2.2.2. Correspondence analysis

Correspondence analysis is an exploratory multivariate technique that helps identify associations between nominal variables when there are no *a priori* expectations about the nature of these associations (Greenacre, 1984; Benzécri, 1992). It is used to simplify complex data sets and to detect structure in them. It simplifies data by using a multi-way crosstabulation table and measures of

correspondence between rows and columns. Variables with lower correspondence measures are more similar and thus, more likely to be simplified as a group in the analysis. As a simplifying technique, correspondence analysis helps reduce a collection of variables (those in Table 3-2 in this case) related to a set of elements (citations, in this case) to groups of variables, which equally describe the elements. Groups of variables are integrated by associations of variables that play an important role in explaining the elements. They are established in 'dimensions' (i.e. axes) that explain the elements in a less complicated way (Hoffman & Franke, 1986; Le Roux & Rouanet, 2004). As a structure detection technique, correspondence analysis helps to plot the elements as a function of the dimensions in what is called a 'correspondence map', which facilitates the detection of patterns. Elements similarly explained by the dimensions are displayed close together. The short distance between the elements indicates tendencies in regards to the dimensions (Greenacre, 1984; Hoffman & Franke, 1986; Benzécri, 1992; Greenacre & Blasius, 1994). It is important to acknowledge that while correspondence analysis is a powerful tool for identifying potential associations between variables and elements, and between variables, it is not related to statistical significance. Therefore, additional statistical tools are required to establish statistical significance of the associations detected (Greenacre, 1984). For that purpose, here the tool used is a Chi-square test, with an established significance level of α-value ≤ 0.05.

In the present work, correspondence analysis was used to explore patterns in the 129 citations based on the three variables describing interdisciplinary characteristics (variables in Table 3-2). It was also used in a secondary analysis to determine if any of the general descriptive characteristics (variables in Table 3-1) are associated with the interdisciplinary descriptive characteristics (variables in Table 3-2). Correspondence analysis was assisted by the software Statistica, version 6.0 (www.statsoft.com).

3.3. Results

3.3.1. Descriptive characteristics

Figure 3-2 presents the relative distributions of descriptive characteristics among the 129 works. It shows that most works are multi-authored (68% [N=88], Box A), and that the majority of corresponding authors are located in the Americas (60% [N=78]), followed by Europe (26% [N=33], Box B). Despite the search beginning in 1970, it is not until 1989 that papers using the term 'interdisciplinary' or related terms started being published. There is a general growth in the use of the terms for interdisciplinary in publications over time until the period between 2005 and 2008, where the number of publications reaches a peak (40% [N=52]). An exception to this increasing trend is the period between 2001 and 2004 where there is a slight decrease in the number of publications (N=28 [22%], Box C). There are five key environment management journals where EM researchers talk about interdisciplinary work; they are: Environmental Management (5% [N=7]), Conservation Biology (5% [N=6]), Hydrobiologia (4% [N=5]), Ecosystems (3% [N=4]) and Aquatic Conservation (3% [N=4]).

However, the bulk of interdisciplinary work seems to appear in a wide variety of journals (80% [N=103], Box D). In addition, most interdisciplinary work is discussed in mixed social and natural sciences' journals (71% [N=92]) as opposed to journals that focus more narrowly on either social sciences (2% [N=2]) or natural sciences research (26% [N=34], Box E). It is also clear that EM research referring to interdisciplinary work appears primarily in those works that utilize keywords related to both the social and the natural sciences (95% [N=122], Box F), and that the most-often used term is 'interdisciplinary' (53% [N=78]) followed by 'multidisciplinary' (34% [N=51], Box G). It is also evident that the word interdisciplinary and related terms most often appear only in the abstract (68% [N=88]), as opposed to the title and/or keywords and abstract (32% [N=41], Box H), suggesting interdisciplinary work is not generally related to the main topic of the research. Finally, most of the EM works using these terms do so without actively engaging with TID (85% [N=110], Box I).

3.3.2. Correspondence analysis

The correspondence analysis simplified the variables delineating interdisciplinary descriptive characteristics in two dimensions that together explain approximately 75% of the 'inertia' (i.e. variance or measure of difference between two or more elements) (Benzécri, 1992) (see Table 3-3). The dimension that explains most of the inertia (Dimension 1, with an eigenvalue, or factor that measures the strength of an axis, of 0.42) accounts for the 44% of inertia. And the second most important dimension (Dimension 2, with an eigenvalue of 0.30) accounts for the 31% of inertia.

Table 3-4 presents the distribution of inertia among interdisciplinary descriptive variables that make up Dimension 1 and Dimension 2 (Greenacre, 1984; Hoffman & Franke, 1986; Le Roux & Rouanet, 2004). It indicates that the variables 'location' and 'objective' have higher contributions to Dimension 1 and are well represented by this dimension (contributions > 0.25; Geigler & Klein, 1994), and that the variable 'terminology' has higher contribution to Dimension 2 and is well represented by it. As a consequence, the variables 'location' and 'objective' define Dimension 1, and the variable 'terminology' defines Dimension 2.

Figure 3-3 presents the resulting correspondence map. The location in the map of the variables defining Dimension 1 (X axis) and Dimension 2 (Y axis) indicates the meaning of the two dimensions. The location of the variables 'location' and 'objective' reveals that Dimension 1 indicates whether works use the term for interdisciplinary in title or keywords and engage with TID (right side of the dimension), or they use the term for interdisciplinary in abstract and do not engage with TID (left side). From the understanding that using the term in title or keywords and at the same time engaging with TID (as opposed to using the term in abstract and not engaging with TID) can be considered an indicator of the importance given in the paper to TID, we can conclude that Dimension 1 represents whether or not the work identifies TID as an important research component. Dimension 1 is thus called: "TID is an important research component / is not an important research component".

The association that Dimension 1 makes between works that refer to interdisciplinary research in title or keyword and engage with TID, as opposed to works that simply use a term in the abstract and do not engage with TID, is statistically significant (χ^2 =9.44, df=1, p=0.002). This suggests that there is a clear distinction between works that do and do not identify TID as an important research component.

When plotting in the map the set of works as a function of Dimension 1, points represent the different works (individual works or multiple works sharing interdisciplinary descriptive characteristics). The distance between a point and the dimension indicates the strength of the association between the point and the variables defining that dimension. Points located too close to the dimension (distance < 0.4; Hoffman & Franke, 1986; Benzécri, 1992) represent works that present a weak association, and those displayed far enough from the dimension (distance > 0.4) represent works that present a strong relation. Therefore, works represented by points falling on the left side of Dimension 1 likely have TID as an important research component, and those represented by points falling on its right side probably do not have TID as a important research component. At first glance it appears that more works fall on the left side, meaning a large body of work engaging with TID. However, in fact only 30 works (24%) clearly fall on the left while 40 (31%) clearly fall on the right. The remaining 57 (45%) are too close to the axis to clearly delineate.

Regarding Dimension 2, the location of the variable ‘terminology’, which defines this dimension, indicates whether works use the term ‘interdisciplinary’ (bottom side) or related terms such as ‘crossdisciplinary’, ‘multidisciplinary’, or ‘transdisciplinary’(top side). Dimension 2 thus identifies whether works use the term ‘interdisciplinary’ as opposed to related terms, and is called: “term ‘interdisciplinary’ / related terms”.

The distinction between works that use ‘interdisciplinary’ and those that use a related term is verified using a cluster analysis. The cluster analysis identified two groups of works that both minimize within-group variation and maximize between-group variation (Everitt et al., 2001): the group integrated by works using the specific term ‘interdisciplinary’, and the group integrated by works using the terms ‘multidisciplinary’, ‘crossdisciplinary’ or ‘transdisciplinary’. Works within each of these two groups are similar among them, and at the same time different from works in the other group (χ^2 =65.76, df=1, p=0.000). It means that there is a clear distinction between works that use ‘interdisciplinary’ and those that use ‘multidisciplinary’, ‘crossdisciplinary’ and ‘transdisciplinary’.

Equivalent to what has been explained for the display of points with regard to Dimension 1, points in the map plotted far enough from Dimension 2 (distance > 0.4) represent works strongly related with Dimension 2. Points strongly related with Dimension 2 and falling on the bottom side of it represent works that likely

use the term ‘interdisciplinary’ only (45 works, 35%), and those falling on the top represent works that likely use related terms (19 works, 15%). The rest of the points are too close to the axis and do not clearly delineate how terminology is used (65 works, 50%).

3.3.2.1. Correspondence map groupings

As presented in Figure 3-3, not all works represented as a function of the dimensions are equally associated to the variables defining the two dimensions. Points plotted close to each other are similarly associated to the two dimensions and can be grouped. Groups of similar points indicate patterns in works in how authors refer to interdisciplinary research. Before evaluating these patterns, points that have a major contribution to any of the two dimensions (i.e. outliers) and points that are not well represented in the map (quality <0.25) for reasons of clarity should be excluded from the analysis (Hoffman & Franke, 1986; Geigler & Klein, 1994). Table 3-5 indicates the distribution of inertia among points. It indicates point D (which represents two works) presents low-quality and should thus not be considered in further steps of the analysis.

Figure 3-3 identifies the remaining 127 works, which based on the proximity among points representing them, are grouped in the following six distinctive groups:

- Group 1 (N=2 [2%]). Works that have TID as an important research component, and use related terms for interdisciplinary such as ‘multi-’, ‘cross-‘ or ‘transdisciplinary’ (points A and B).
- Group 2 (N=23 [18%]). Works that have TID research as an important research component, and use both the term ‘interdisciplinary’ and related terms such as ‘multi-’, ‘cross-‘ or ‘transdisciplinary’, skewed either toward the use of related terms (point C, and to a lesser degree E) or toward the use of the term ‘interdisciplinary’ (point F, and to a lesser degree G).
- Group 3 (N=5 [4%]). Works that have TID as an important research component, and use the term ‘interdisciplinary’ only (point H).
- Group 4 (N=17 [13%]). Works that have TID as an important research component, biased toward not having TID as an important research component (point I and to a slightly lesser degree J), and that use related terms for interdisciplinary such as ‘multi-’, ‘cross-‘ or ‘transdisciplinary’.
- Group 5 (N=40 [31%]). Works that do not have TID as an important research component, biased toward having TID as an important research component, and that use the term ‘interdisciplinary’ (point K).
- Group 6 (N=40 [31%]). Works that do not have TID as an important research component, and use both the term ‘interdisciplinary’ and other related terms, skewed either towards using interdisciplinary (point L) or toward using related terms (point M and to a lesser degree N).

Table 3-6 presents the bibliographic references corresponding to the points distributed in the different groups.

The six groups indicate that there is a pattern in papers based on the interdisciplinary descriptive variables. Works that do **not** have TID as an important research component tend to use the interdisciplinary terms indistinctly. In other words, where TID is not engaged, little differentiation appears among the use of 'inter-' or any of its related terms. By comparison, works that **do** include TID as an important research component follow three tendencies: those that use the term 'interdisciplinary' and its related terms interchangeably, those that use the related terms, and those that specifically employ the term 'interdisciplinary.'

3.3.2.2. Interdisciplinary and general descriptive characteristics

A secondary analysis consisted of displaying the general descriptive characteristics on the map to interpret the position of the different variables with regard to the two dimensions, which represent interdisciplinary descriptive characteristics. Figure 3-4 presents the resulting set of correspondence maps. Positions of the different variables show there is no indication of association between interdisciplinary descriptive characteristics and the variables: number of authors (Box A), year (Box C), and journal name (Box D).

However, the remaining three boxes do provide important findings. First, Box B suggests that works with corresponding authors located in Asia are more likely to have TID as an important research component, as compared to those with corresponding authors located in Africa, which are more likely to **not** include TID as important in the research. Second, Box E indicates that works published in social sciences journals are more likely to have TID as an important research component. By comparison, works published in natural sciences journals are more likely to **not** have TID as an important research component. Finally, Box F suggests that works using keywords related to both the social and the natural sciences are more likely to have TID as an important research component, while works using keywords related exclusively to the natural sciences are more likely **not** to have TID as an important research component. In conclusion, there is indication of associations between the importance of TID and the variables: country, type of journal, and keywords classification.

Table 3-7 indicates the distribution of inertia among general descriptive variables. The low values of the contributions to inertia of categories explained by the two dimensions, and the low values of overall quality of the variables (value < 0.25) show that the possible associations detected must be treated with caution (Greenacre, 1984; Hoffman & Franke, 1986; Benzécri, 1992; Geigler & Klein, 1994). Statistical analysis on the associations detected indicates that while the relation between the importance of TID and the country and between the importance of TID and keywords classifications are not significant (χ^2 =1.2, df=1, p=0.273, and χ^2 =2.16, df=1, p=0.141, respectively), the relation between the importance of TID and journal type is significant (χ^2 =13.95, df=1, p=0.000). However, in all three cases significance is not ensured due to the low counts of works in the different categories for journal name, type of journal, and keywords classification, and having TID as an important and not important research component.

3.4. Discussion

In the EM literature there is a claim about the importance of interdisciplinary work (Endter-Wada et al., 1998; Meffe et al., 2002). Findings from our study provide preliminary evidence that attempts are being made to answer to this call. However, increased interdisciplinary practice does not necessarily mean that the work is being conducted in a critically-reflective manner, or that it is progressing toward recommended 'best practices' of interdisciplinary work (Szostak, 2003; Newell, 2007; Barry et al., 2008; Klein, 2008).

Of the 30,757 papers published in EM since 1970 (on ISI Web of Science) this research discovered only 129 works mentioning interdisciplinary work, representing less than one-half of one percent of total EM works. In additional, while just over a few of the identified works engage with TID (15%), the majority (85%) do not. So while claims are being made in the field about the importance of interdisciplinary work, that importance does not seem to be clearly articulated in the peer-reviewed literature by authors self-identifying themselves as 'interdisciplinary' through utilization of such term. In addition, among those EM researchers that do engage in TID there is considerable heterogeneity in how the terms are employed. Finally, those EM works that do engage TID tend to show preference for using the term 'interdisciplinary' or a specific related terms of it (as opposed to use the terms indistinctly), and tend to be found in social science journals (as opposed to natural science journals). There are at least three inter-related factors that could explain these findings: institutional constraints, language, and epistemological and ontological distances.

3.4.1. Institutional constraints

There is well-established literature discussing the role that institutional constraints play in researchers' decisions regarding publication (see, for example, Becher & Trowler, 2001). Academic environments, in particular, have been especially criticized for administrative structures based on faculties and departments, resulting in 'silos' of knowledge working independently and with little interaction (Salter & Hearn, 1996; Kandiko & Blackmore, 2008). Within this structure academic researchers are rewarded for increasing levels of expertise in their field through salary and award processes and there is considerable pressure (especially on junior faculty) to publish in highly-ranked, discipline-specific journals. Through the tenure and reward system credibility as an academic is established by showing one's expertise in a given field, as represented by publications in journals with a high impact factor. The peer-review process feeds this system by 'disciplining' authors to write to specific audiences and communicate using specific language (Foucault, 1972), thereby, controlling the value and quality of research in a particular discipline (Zuckerman & Merton, 1971; Berardo, 1981; Kiesler, 1991). As Barry et al. (2008, p. 20) point out: 'disciplines discipline disciples'.

Because journals act as discussion channels within such academic communities (Zuckerman & Merton, 1971; Campanario, 1998) they tend to focus on limited

phenomena and employ a specific set of theories, methods, and rules reflecting disciplinary perspectives (Klein, 1990; Salter & Hearn, 1996; Klein, 1996; Szostak, 2003; Repko, 2008). Journals are means by which the value and quality of scientific research in a particular discipline are controlled (Zuckerman & Merton, 1971; Berardo, 1981; Kiesler, 1991). Traditions and quality standards differ across disciplines, especially when considering the social and natural sciences (Zuckerman & Merton, 1971; Wanner et al., 1981; Martinko et al., 2000). For researchers therefore, it is efficacious to publish and read deeply in the journals within their field (Campbell, 2005; Langfeldt, 2006). Previous research on academics suggests that researchers rarely cite literature outside their own field, and do not generally participate in debates traditionally considered the domain of others. This may be deemed inappropriate not only by journal editorial boards, but also by the academic tenure and reward systems mentioned earlier (Wanner et al., 1981; Fox, 1989; Nyhus et al., 2002).

Though claiming to be interdisciplinary, EM has well-established, historical roots in ecology (Kennedy, 1991; Grumbine, 1994; Blockstein, 1999) so the philosophical, ontological, and epistemological preferences of natural science tend to dominate the field (Redclift, 1998; Lele & Norgaard, 2005; Evely et al., 2008). In addition, EM research projects are generally led by natural scientists (Kennedy, 1991; Blockstein, 1999) who normally publish in the natural sciences literature, and rarely consult and use social sciences literature (MacMynowski, 2007). And it is within that social sciences literature that most of the discussion of interdisciplinary theory has taken place over the past decade (Klein, 2000; Repko, 2008). It is therefore not at all surprising that EM authors tend not to identify their work as interdisciplinary, and that even when they do, just a few of them actually engage with TID in the course of their work.

3.4.2. Language

To be sure, an important component of the publication process is related to how researchers invoke disciplinary language to establish credibility and to gain respect. This project found that EM authors that do engage with TID show a tendency for preferring either the term ‘interdisciplinary’ or its related terms, while those that do not engage with TID tend to use terms indiscriminately. Meanwhile, within the TID literature, there are important and clear distinctions between terms such as ‘interdisciplinary,’ ‘multidisciplinary,’ ‘crossdisciplinary,’ and ‘transdisciplinary’[7] as theorists discuss the meaning, purpose, and ideal practice of interdisciplinary research (Chubin et al., 1986; Klein, 2000; Repko, 2008). However, it seems clear that such distinctions are little considered among the EM literature found here. However, our data do suggest that some researchers are discriminating between specific terms – implying that EM researchers may be beginning to more carefully invoke specific terms as they become more engaged with TID. This conclusion is further supported by our finding that EM researchers engaging with TID also use interdisciplinary terms in the title and keyword of

[7] For a detailed discussion of terminology refer for example to: Jantsch, 1970; Swanson, 1979; Klein, 1990; Weingart & Stehr, 2000; Lattuca, 2001; Van Kerkhoff, 2005; Tress et al., 2005.

their works (as opposed to just using it in passing in the abstract), again suggesting that some researchers are starting to understand the importance of invoking the language of TID.

3.4.3. Epistemological and ontological distances (between natural and social scientists)

One key challenge of EM is bringing together natural and social scientists, who have different underlying philosophies (Evely et al., 2008). Some researchers have suggested that social science has traditionally played a subordinate role to natural science in EM, reflecting the perspective that the role of social science is simply to make natural science more accessible to governments, the public, and markets (Grumbine, 1994; Endter-Wada et al., 1998; Nyhus et al., 2002). Rooted in epistemological and ontological distances between collaborators (Garvin, 2001), such philosophical differences can be daunting for EM researchers (Evely et al., 2008).

Such challenges are not unique to EM (Moran, 2002). Even fields recognized as 'bridging' disciplines are confronted with accommodating disparate philosophical approaches and heterogeneity both within and between disciplines (Younglood, 2007). While our findings do not support the claim that EM is, in practice, an 'interdisciplinary' field based on classifications within the interdisciplinarity literature (Newell, 2001; Szostak, 2002; Klein, 2008), our findings do suggest that EM researchers are making the first steps to engage with the 'logics of ontology' of interdisciplinary work (Barry et al., 2008), as indicated by the fact that some EM researchers engage TID and publish in journals traditionally used by social scientists.

3.5. Conclusions

The research reported here found that to date EM researchers have shown little engagement with the theoretical literature on interdisciplinary research. This is most likely due to three convergent factors: institutional constraints, language, and epistemological/ontological distances between natural and social scientists. However, findings also suggest that TID are starting to be integrated into the EM literature. Some researchers are showing a burgeoning interest in advancing theoretical considerations about interdisciplinary activity in their field. Due to the descriptive nature of the data collected here however, definitive explanations for the barriers preventing a stronger engagement with TID can only be postulated at present. The work reported here lays the groundwork for a more detailed understanding and theorizing of interdisciplinary research and practice within the heterogeneous field of EM, as developed in Chapter 4.

3.6. Tables and figures

3.6.1. Tables

Table 3-1. General descriptive characteristics

Variable Name	Definition	Categories
Number of authors	Number of authors publishing the paper	1 author 2-4 authors > 4 authors
Continent	Geographic location of the corresponding author's institution	Africa the Americas Asia Europe Oceania
Year	Publication period	<1989 1989-1992 1993-1996 1997-2000 2001-2004 2005-2008
Journal name	Journal where papers are published*	Aquatic Conservation Conservation Biology Ecosystems Environmental Management Hydrobiologia Other
Type of journal	Journal publishing social and/or natural sciences issues	Social sciences Natural sciences Mixed social and natural sciences Unable to categorize
Keywords classification	Keywords related to the social and/or natural sciences	Social sciences Natural sciences Mixed social and natural sciences Unable to categorize

* The five journals listed are the most frequently used

Table 3-2. Interdisciplinary descriptive characteristics

Variable Name	Definition	Categories
Terminology	Word used to represent interdisciplinary work	'Interdisciplinary' Related terms*
Location	Where the term appears in the work	Title or keywords Abstract
Objective	Focus of the study being reported	Engages with TID Does not engage with TID

* The category 'related terms' includes the following terms: 'crossdisciplinary', 'multidisciplinary', 'transdisciplinary', and 'pluridisciplinary'.

TID = Theory of interdisciplinary research

Table 3-3. Determination of number of dimensions

		Percentage of inertia	
Dimension	Eigenvalues	Accounted for	Cumulative
1	0.42	43.81	43.81
2	0.30	30.92	74.73

Total Inertia=0.96; Chi-square: 373.10; significance: 1; degrees of freedom: 640

Table 3-4. Distribution of inertia among interdisciplinary descriptive variables

Variable				Contribution of category to inertia of		Contribution to inertia of categories by	
Name	Category*	Quality	Relative inertia	Dim.1	Dim.2	Dim.1	Dim.2
Terminology	trm_ID	0.8305†	0.1395	0.0386	0.3201‡	0.1211	0.7094†
	trm_rld	0.8305†	0.1690	0.0467	0.3877‡	0.1211	0.7094†
Location	lct_tl	0.7756†	0.2359	0.2853‡	0.1874	0.5299†	0.2456
	lct_abs	0.7756†	0.1099	0.1329‡	0.0873	0.5299†	0.2456
Objective	obj_TID	0.6449†	0.2948	0.4234‡	0.0149	0.6292†	0.0157
	obj_n_TID	0.6449†	0.0509	0.0731‡	0.0026	0.6292†	0.0157

* Categories included are: ‘trm_ID’: term is ‘interdisciplinary’; ‘trm_rld’: term is a related term; ‘lct_tl’: term is located in title or keywords; ‘lct_abst’: term is located in abstract; ‘obj_TID’: objective indicates work engages with TID; and, ‘obj_n_TID’: objective indicates work does not engage with TID

† Values of high contribution to inertia of categories by Dimensions 1 and 2 (contribution > 0.25) and high values of overall quality (quality > 0.25)

‡ Values of high contribution of categories to inertia of Dimensions 1 and 2

Table 3-5. Distributions of inertia among points

			Contribution			
			of points to inertia of		to inertia of points by	
Point	Quality	Relative inertia	Dim.1	Dim.2	Dim.1	Dim.2
A	0.7960*	0.0245	0.0330	0.0164	0.5892*	0.2068
B	0.8613*	0.0218	0.0388	0.0057	0.7801*	0.0812
C	0.8960*	0.0213	0.0418	0.0024	0.8606*	0.0354
D	0.1249	0.0200	0.0053	0.0005	0.1165	0.0083
E	0.2702*	0.0084	0.0052	0.0000	0.2691*	0.0011
F	0.2966*	0.0168	0.0092	0.0031	0.2400	0.0566
G	0.9767*	0.0235	0.0517	0.0009	0.9653*	0.0113
H	0.6191*	0.0190	0.0141	0.0180	0.3260*	0.2931*
I	0.5193*	0.0062	0.0024	0.0071	0.1686	0.3507*
J	0.8977*	0.0095	0.0007	0.0265	0.0314	0.8663*
K	0.9280*	0.0039	0.0013	0.0099	0.1502	0.7777*
L	0.9730*	0.0017	0.0036	0.0004	0.8970*	0.0760
M	0.8123*	0.0050	0.0068	0.0034	0.6024*	0.2100
N	0.9017*	0.0022	0.0045	0.0000	0.8974*	0.0043

Points are individual works or multiple works that share interdisciplinary descriptive characteristics. The number of works included in the different points are: 1 in A, 1 in B, 3 in C, 2 in D, 13 in E, 1 in F, 6 in G, 5 in H, 5 in I, 12 in J, 40 in K, 3 in L, 36 in M, 1 in N

* Values of high contribution to inertia of points by Dimensions 1 and 2 (contribution > 0.25) and high values of overall quality (quality > 0.25)

Table 3-6. Bibliographic references

Group	Point	Bibliographic reference*
1	A	Wilson & Lantz, 2000
	B	Musser & Ahearn, 1997
2	C	Jakobsen et al., 2004; Jakobsen & McLaughlin, 2004; Naveh, 2005
	E	Bragg & Kershner, 1999; Buchner, 1995; Chadwick et al., 2008; Cumming et al., 2005; Gentry, 2007; Gutrich et al., 2005; Hambright & Zohary, 1998; Henry & Amoros, 1995; Korfmacher, 2002; Newson, 2002; Sekino & Nakamura, 2006; Sturtevant et al., 2007; Webb & Raffaelli, 2008
	F	Nilsson et al., 2003
	G	Casagrande et al., 2007; Clark, 1999; Hodgson et al., 2007; Lundberg, 2005; Milon et al., 1997; Wätzold et al., 2006
	H	Brodziak & Link, 2002; Gillson & Willis, 2004; Peterson et al., 2000b; Phillips & Randolph, 2000; Rohlf & Dobkin, 2005
3	I	Moelsae et al., 1999; Oliver & Powers, 1998; Periman, 2005; Peterson et al., 2000a; Wishart & Davies, 2002
4	J	Biggs et al., 2000; Burgess et al., 1999; Elashry, 1994; Hillman & Brierley, 2005; Hillman et al., 2005; Kato & Ahern, 2008; Lepofsky et al., 2003; Naveh, 2000; Norgaard, 2008; Pedersen et al., 2006; Shastri et al., 2008; Singer & Karsenty, 2008
	K	Ahn et al., 2004; Berkes, 2004; Bridgewater, 2002; Carden, 2006; Carpenter & Folke, 2006; Clark et al., 2001; Culp et al., 2000a; Culp et al., 2000b; Danby & Slocombe, 2005; Firth, 1998; Franklin et al., 1999; Ganio & Puettmann, 2008; Grandy & Neff, 2008; Grant & Quinn, 2007; Gruen, 2007; Halpern et al., 1999; Harwell, 1997; Hein et al., 2006; Jackson, 2007; Jax & Rozzi, 2004; Kellogg, 1998; Leuschner & Scherer, 1989; Loomis et al., 2000; MacKenzie, 1993; Newton, 1999; Noss, 1999; Parlee et al., 2005; Parr et al., 2003; Poiani et al., 1998; Rabeni et al., 2002; Rees et al., 2008; Robertson, 2000; Soto, 2001; Sutter et al., 2005; Stefanovic , 1997; Turner, 2000; Vitousek, 2006; Wang, 2004; Yang & Yang, 2005; Zalewski et al., 2003
5	L	Glaser, 2006; Mitchell, 2008; Thatje et al., 2008
6	M	Agardy et al., 2003; Cormier-Salem, 1999; D'Ayala, 1992; Els & Bothma, 2000; Fazey et al., 2005; Haag & Kaupenjohann, 2001; Halse & Massenbauer, 2005; Hambright et al., 1998; Harrison et al., 2005; Hession et al., 2000; Jankovska & Pokorny, 2002; Jarre et al., 2008; Keough & Blahna, 2006; Kirkman et al., 1999; Kline et al., 2001; Ladson et al., 1999; Larsen et al., 1997; Lautenschlager et al., 1997; Le Chevalier et al., 2007; Lefeuvre, 2007; Loiselle et al., 2001; Luloff et al., 1996; Mumby et al., 2008; Navehhis, 2000; Nichols, 1996; Quon et al., 2001; Rao, 2005; Robertson et al., 2007; Sherman, 1994; Slocombe, 1998; Smythe et al., 1996; Steffan-Dewenter et al., 2007; Temperton, 2007; Vaughan et al., 2001; Walkerden, 2006 ; Weinstein , 2008
	N	Johnson et al., 2003

* Complete references are provided in Appendix 1

Table 3-7. Distributions of inertia among general descriptive characteristics

Variable			Contribution to inertia of categories by	
Name	Category	Quality	Dim.1	Dim.2
Number of authors	1 author	0.0211	0.0119	0.0092
	2-4 authors	0.0154	0.0059	0.0096
	> authors	0.0011	0.0010	0.0001
Continent	Africa	0.0420	0.0127	0.0293
	the Americas	0.0371	0.0006	0.0365
	Asia	0.0278	0.0077	0.0201
	Europe	0.0018	0.0008	0.0010
	Oceania	0.0486	0.0094	0.0392
Year	1989-1992	0.0081	0.0072	0.0009
	1993-1996	0.0177	0.0052	0.0125
	1997-2000	0.0020	0.0011	0.0009
	2001-2004	0.0126	0.0000	0.0126
	2005-2008	0.0061	0.0005	0.0057
Journal name	Aquatic Conservation	0.0114	0.0005	0.0109
	Conservation Biology	0.0051	0.0051	0.0000
	Ecosystems	0.0028	0.0006	0.0022
	Environmental Management	0.0042	0.0006	0.0035
	Hydrobiologia	0.0431	0.0062	0.0369
	Other	0.0241	0.0002	0.0239
Type of journal	Social sciences	0.1069	0.1051	0.0017
	Natural sciences	0.0571	0.0528	0.0043
	Mixed social and natural sciences	0.0270	0.0229	0.0041
	Unable to categorize	0.0103	0.0069	0.0034
Keywords classification	Social sciences	0.0084	0.0015	0.0069
	Natural sciences	0.0163	0.0080	0.0083
	Mixed social and natural sciences	0.0448	0.0391	0.0058
	Unable to categorize	0.0081	0.0072	0.0009

3.6.2. Figures

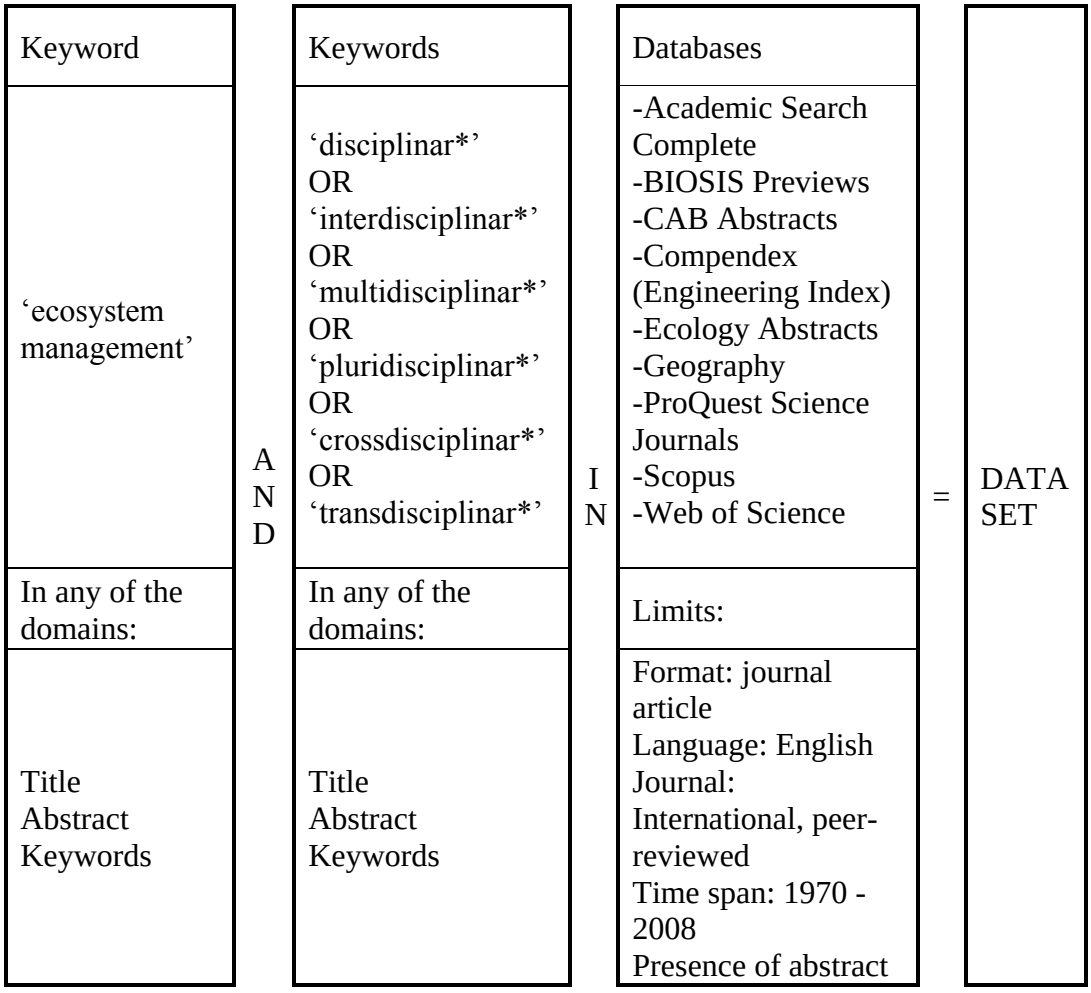

Figure 3-1. Data collection strategy

* Indicates wildcard. Using this convention permits the capture of any permutation of the search word. For example, interdisciplin* will capture interdisciplinary, interdisciplinarity, interdisciplining, interdisciplinated, and so on.

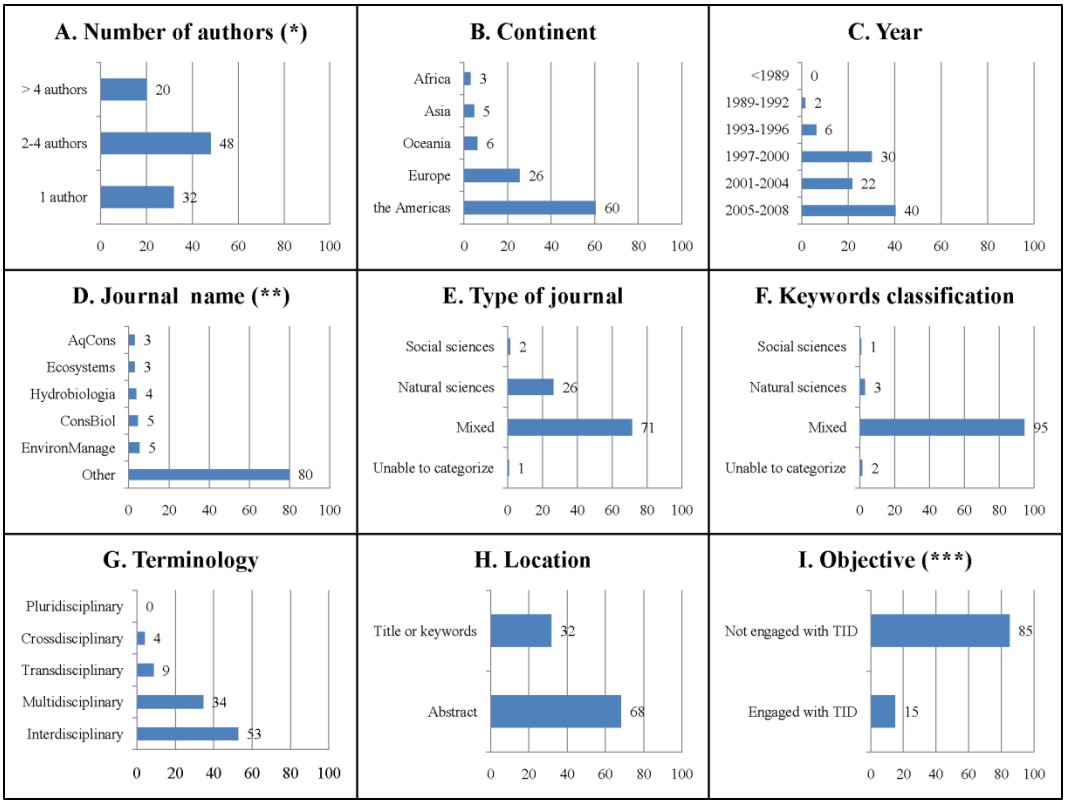

Figure 3-2. Distributions of descriptive characteristics

(*) Mode = 1, minimum =1, maximum = 14, median = 2

(**) The five journals displayed are the five journals more frequently used among papers. Abbreviations included are: AqConserv for Aquatic Conservation, ConsBiol for Conservation Biology, and EnvManage for Environmental Management

(***) TID = Theory of interdisciplinary research

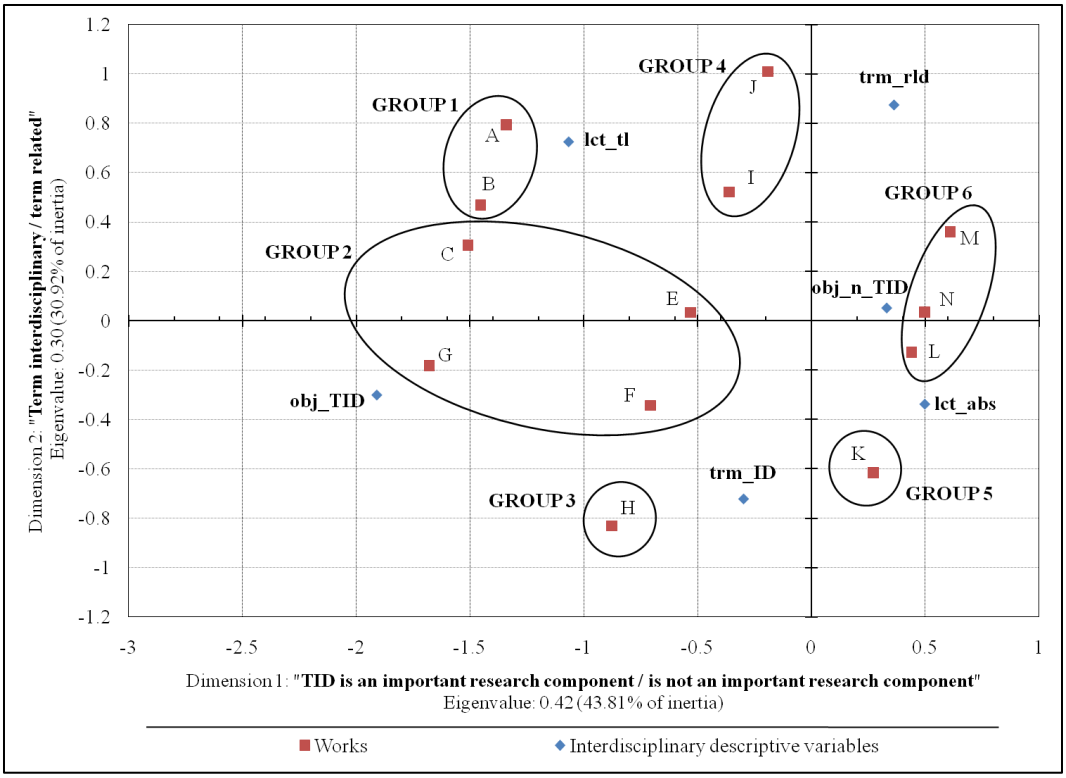

Figure 3-3. Correspondence map**.** Groups represented by numbers (Group 1, Group 2 and so on) are broad sets of works identified as having similar interdisciplinary descriptive characteristics representing Dimensions 1 and 2.

Categories included are: 'trm_ID': term is 'interdisciplinary'; 'trm_rld': term is a related term; 'lct_tl': term is located in title or keywords; 'lct_abst': term is located in abstract; 'obj_TID': objective indicates work engages with TID; and, 'obj_n_TID': objective indicates work does not engage with TID.

Boxes identified by letters (A, B, C and so on) are individual works or multiple works represented by the same point and therefore sharing interdisciplinary descriptive characteristics.

TID = Theory of interdisciplinary research

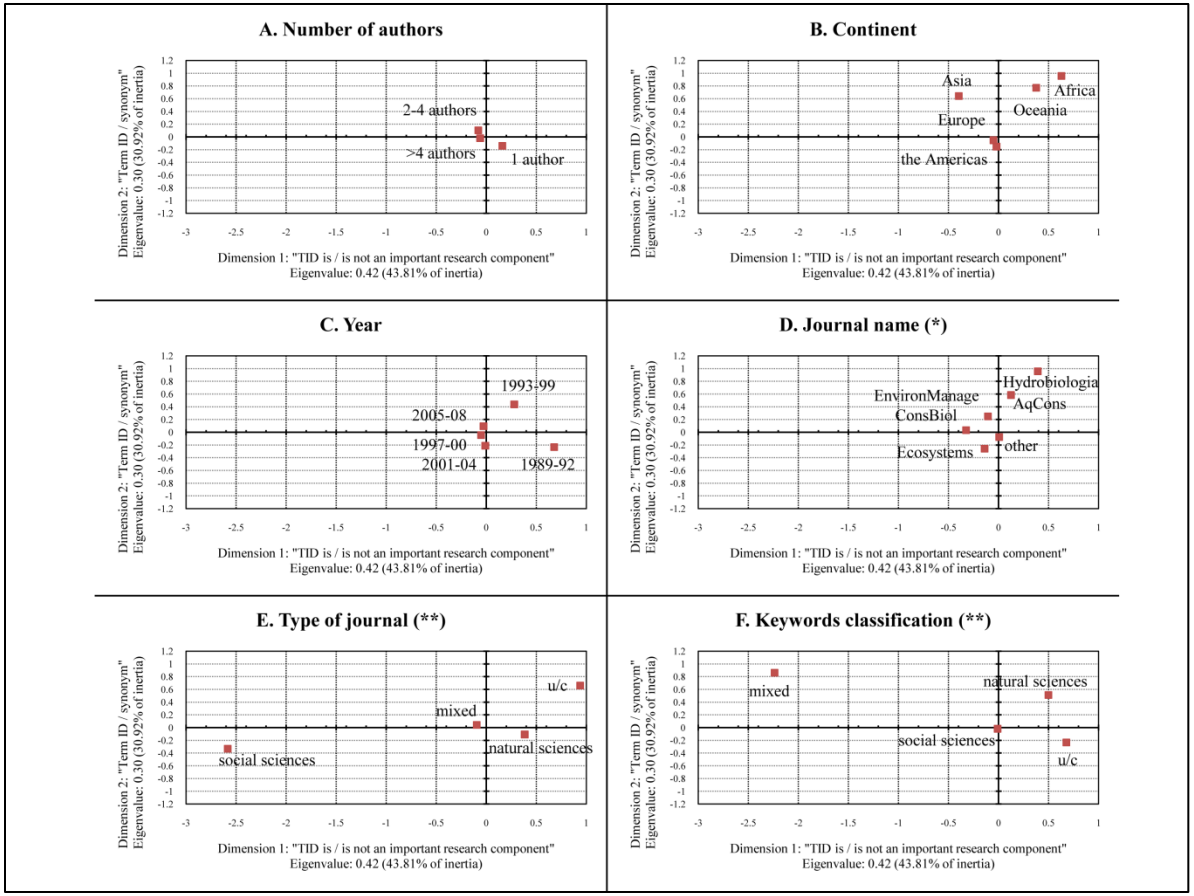

Figure 3-4. Interdisciplinary and general descriptive characteristics
ID = 'Interdisciplinary', TID = Theory of interdisciplinary research. Other abbreviations used are: (*) AqConserv for Aquatic Conservation, ConsBiol for Conservation Biology, and EnvManage for Environmental Management; and, (**) u/c for unable to categorize.

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CHAPTER 4

CLARIFYING THE CONCEPT OF INTERDISCIPLINARITY
A QUESTIONNAIRE SURVEY

4.1. Introduction

This chapter uses a questionnaire survey[8] to investigate how EM researchers define interdisciplinary research. It focuses on the views of 119 researchers who wrote the collection of academic papers analyzed in the previous chapter (Chapter 3. Literature Evaluation). It confirms and extends preliminary conclusions from the Literature Evaluation about theoretical considerations regarding interdisciplinary work in the EM field by making explicit distinct and shared understandings of interdisciplinary research among a set of EM researchers.

4.2. Methods

This chapter evaluates the responses of individuals who participated in an online questionnaire. Potential participants were identified from the bibliometric analysis conducted in the Literature Evaluation. The Questionnaire Survey identified a total of 218 potential participants who were first, second and corresponding authors of the 129 English language, international, peer-reviewed EM journal articles analyzed in the Literature Evaluation. Authors were sent an invitation e-mail containing the link to the website where the questionnaire was posted. Invitations were personalized and indicated the name of the publication that identified them as qualified participants. After two follow-up remainders 119 authors completed the questionnaire, resulting in a response rate of 55%.

An initial questionnaire format was designed and modified following the suggestions of 15 environmental sciences' researchers who participated in two sequential pre-tests. After modifications, the survey included two sections of questions[9]. One section asked participants' understandings of the concept of interdisciplinary work (see Table 4-1 for a list of variables and categories included). The second section asked respondents' personal characteristics and their relationship with theories of interdisciplinary work (see Table 4-2). Personal characteristics included traits such as gender, area of academic degree, primary professional occupation, and country of residence. Respondents' relationship with theories of interdisciplinary work included their familiarity with such theories, and the importance they attribute to theoretical discussions about interdisciplinary work.

[8] Certificates of ethics approval for this study are presented in Appendix 2.

[9] These two sections refer to the information from the questionnaire that was used for writing this chapter. For a complete view of all the information included in the questionnaire see the questionnaire format, which is presented in Appendix 3.

4.2.1. Data analysis

Data analysis took place in two stages. The first stage involved cluster analysis describing researchers' definition of interdisciplinary work based on both distinct and shared understandings of the concept. It also identified groups of people with particular understandings based on personal characteristics and the relationship they have with theories of interdisciplinary work. The second stage employed logistic regression analysis to analyze how personal characteristics of respondents and their particular relationship with theories of interdisciplinary work predict whether a respondent is related to a certain understanding of interdisciplinary work.

4.2.1.1. Cluster Analysis

An agglomerative hierarchical clustering technique grouped respondents based on their interpretation of the concept of interdisciplinary research. Cluster analysis seeks to identify a set of groups (i.e. clusters), which both minimize within-group variation and maximize between-group variation (Tryon & Bailey, 1970; Anderberg, 1973; Everitt et al., 2001). Hierarchical clustering starts with the assumption that in each step the two groups with the smallest dissimilarity (or the highest similarity) are merged until all cases (respondents in this case) are in one single group. To compute dissimilarities and join respondents the process used squared Euclidian distance measures defined with Ward's linkage method (minimum variance method; Ward, 1963; Romesburg, 1990).

The analysis excluded respondents with missing values for any of the 19 categories related to the concept of interdisciplinary research (variables in Table 4-1). As a result, it included 107 respondents and the 19 binary (i.e. presence/absence) categories.

There are no standard objective criteria to determine the optimum number of groups resulting from the analysis (Hair et al., 1987). The criteria used here were: 1) the number of respondents within each group, 2) the level of dissimilarity of the two groups joined at every step, and 3) the possibility to categorize the groups (Everitt et al., 2001; Janssens, 2008). The ideal solution does not have a low frequency of respondents (4 or less; Janssens 2008) for one or more groups, does not involve the union of two very dissimilar groups, and contains groups that can be assigned significant and unambiguous meaning. The determination of in what steps of the analysis the more dissimilar groups are joined to constitute a new group is based on the interpretation of the agglomeration schedule and dendogram (or tree diagram). The dendogram visually represents the information on the agglomeration schedule. The agglomeration schedule contains dissimilarity (i.e. distance) values between every two cases linked at every step until arriving at a single group solution.

In our case, the groups resulting from the analysis indicate groups of researchers with views of the concept of interdisciplinary research that are similar between them and at the same time distinctive from the rest of respondents, as indicated by interdisciplinary variables (those in Table 4-1). From the description of the

different groups of respondents and the interdisciplinary variables they have related, it is possible to conclude understandings of the concept that are distinct among the different groups and understandings that are shared by the whole set of respondents. Distinct and shared understandings are established by tests of statistical significance. Here, the process used a Chi-square test, which had established as significance level an α-value ≤ 0.05. A significant association between a variable and any of the groups means this group is significantly different to the rest of groups in relation to the variable. Therefore, significance in associations suggests distinct understandings of the concept among groups of respondents. A non-significant association between a variable and any of the groups means that any of the groups are not significantly different from the rest in relation to the variable. The high presence of this variable among people in all groups indicates this variable describes shared understandings of interdisciplinary work among the whole set of respondents.

4.2.1.2. Logistic Regression

A logistic regression analysis was employed to identify variables that determine distinct understandings of the concept of interdisciplinary work identified in the cluster analysis. This analysis constructs a statistical model that helps predict a discrete outcome (group membership, in this case) from one –or a combination of– explanatory variables (personal characteristics and relationship with theories of interdisciplinary work presented in Table 4-2, in this case) (Long, 1997; Vittinghoff, 2005; Tabachnick, 2007).

After excluding respondents with missing values for any of the categories, 105 respondents were included. The analysis included respondents' group membership, and their personal characteristics and relationship with theories of interdisciplinary work. A significant statistical association between membership in a certain group and any personal characteristic or particular relationship with theories of interdisciplinary work (p-value ≤ 0.05) indicates a statistically significant association between this characteristic or relationship and group membership.

The model resulting from the regression is expressed by predictor coefficients (with standard errors of estimate and significance levels), and an odds ratio (with certain confidence interval) associated to each predictor coefficient. The odds ratio associated to each predictor indicates the anticipated outcome (Tabachnick & Fidell, 2007). Since logistic regression considers only dichotomous variables (i.e. takes only two values, which usually represent the occurrence or non-occurrence of some event; membership to Group 1 or no membership to Group 1, for example), the different groups analyzed are in relation to one 'reference category'. The odds ratio associated to each predictor shows the number of times one category (e.g. membership to Groups 2, 3, and so on) is present as compared with a 'reference category' defined for that variable (e.g. membership to Group 1).

4.3. Results

Three main findings emerged from the data. First, respondents share a definition of interdisciplinary work, but differ on the terminology they tend to use to refer to it. Second, respondents are generally not familiar with theoretical discussions about interdisciplinary work. Third, familiarity with theoretical considerations regarding interdisciplinary research explains differences in tendencies in the use of terminology.

4.3.1. Definition of interdisciplinary work

The cluster analysis divided the set of respondents into two groups based on how they define interdisciplinary work using the variables in Table 4-1. Figure 4-1 presents the two groups resulting from the analysis. The 2-group solution was chosen from seven initial solutions integrated by two to eight groups and following the selection criteria defined above. The criteria of number of respondents within each group selected the solution integrated by two, three, four and five groups. The criteria of dissimilarity levels between groups joined at every step selected the 2- and 3-group solution, as shown by the large differences in dissimilarity coefficients in the agglomeration schedule in Table 4-3 and the dendogram in Figure 4-1. Finally, the criteria indicating the possibility to assign significant and unambiguous meaning to the groups selected the 2-group solution. The 2-group solution is associated with a meaningful and clear message. As shown below, the two groups differ on the terminology they tend to use for interdisciplinary research. On the other hand, the 3-group solution had ambiguous meaning.

Further information about the resulting groups of people with particular interpretations of the concept of interdisciplinary work is presented in Table 4-4. Table 4-4 provides frequency distributions of the categories for Group 1 and Group 2 (second column for Group 1 and third column for Group 2), which describe the understanding of interdisciplinary work of people in each group, and allow a comparison between understandings in the two groups. Table 4-4 also presents results from the crosstabulation analysis performed on the categories and the respondents' group membership, which determines the distinct understandings of the concept in Group 1 and Group 2. Table 4-4 finally indicates frequency distributions of the interdisciplinary categories in the set of the two groups (third column), which together with frequency distributions for Group 1 and 2 helps interpreting understandings of the concept shared among the whole set of respondents.

4.3.1.1. Distinct understandings

Under the variable 'synonyms' in Table 4-4, higher percentages of Group 2 members as compared to percentages of respondents in Group 1 indicated that they think that 'interdisciplinary' is synonym with 'multidisciplinary', 'crossdisciplinary', 'transdisciplinary' and 'pluridisciplinary'. A Chi-square test was performed for all categories except 'pluridisciplinary', which had not enough counts to allow the correct performance of the analysis. The categories

‘multidisciplinary’, ‘crossdisciplinary’ and ‘transdisciplinary’ had p-values lower than 0.05, indicating Group 1 and Group 2 are significantly different regarding these categories. Significant differences suggest that within the whole set of respondents there are two distinct understandings of the concept of interdisciplinary work:

- Understanding 1. No, interdisciplinary **is not** a synonym with multidisciplinary, crossdisciplinary, or transdisciplinary.
- Understanding 2. Yes, interdisciplinary **is a** synonym with multidisciplinary, crossdisciplinary, or transdisciplinary.

Group 1 tends to make the distinction between terms, and Group 2 tends not to make this distinction. Group 1 is therefore called ‘Group tendency no synonyms’ and Group 2 is called ‘Group tendency synonyms’.

4.3.1.2. Shared understandings

Under the variable ‘definition’ in Table 4-4, Group 1 and Group 2 members indicated they have similar understandings about what interdisciplinary work is. Although there are slight differences in the rates of people in each group indicating specific definitions, in all the cases where the Chi-square analysis could be performed, p-values are higher than 0.05 indicating differences are not statistically significant. Percentages over 70% of overall respondents under the categories ‘is a research process’ and ‘is a philosophy’ indicate that interdisciplinary work is generally defined as a research process and a philosophy or way of thinking about research. Percentages lower than 15% of overall respondents under the categories ‘is a search’, ‘is a discipline’, ‘is a critique’, ‘is a social movement’, and ‘is a claim’ indicate that interdisciplinary work is not commonly defined as a search for universal knowledge, a discipline, a critique against disciplinarity, a social movement, or a claim for political and social equity.

In a similar way, under the variable ‘related research’ in Table 4-4 there are small differences in the relative presence of the categories in Groups 1 and 2. However, differences were not determined statistically significant by Chi-square tests (p-values > 0.05). Over 70% of participants indicated they relate interdisciplinary work to collaborative and problem solving research.

Under the variable ‘social actor’ in Table 4-4, the category ‘outside academia’ is equally absent in both groups, indicating all respondents (no matter what group they belong to) do not see interdisciplinary work as involving social actors exclusively outside academia. Below 10% of survey respondents indicated that interdisciplinary work takes place exclusively inside academia, and over 90% indicated that it takes place both inside and outside academia. While there appear to be minor differences between the two groups, statistically significant differences regarding this variable could not be determined.

Finally, under the variable ‘group size’ there are similar proportions of Group 1 and Group 2 members indicating different sizes of groups doing interdisciplinary

work. As for previously described variables, differences of percentages between groups were not determined statistically significant by Chi-square tests. Over 80% of overall respondents indicated that group sizes are of two to four people or more than four people, and less than 35% indicated that groups are integrated by one single person.

Summarizing, most respondents share the following understanding of interdisciplinary work:

> Interdisciplinary work is a research process for linking (integrating) information, and a philosophy or way of thinking about research. It is not a search for universal knowledge, a discipline, a critique against disciplinarity, a social movement (ideology), or a claim for political and social equity. It is related to collaborative research and problem-solving research. It does not involve social actors exclusively outside academia or exclusively in academia, but involves both. It is conducted by two or more people and not by a single person.

4.3.2. Description of respondents

Table 4-5 presents frequency distributions and chi-squares for categories related to personal characteristics and relationship of respondents with theories of interdisciplinary work. Frequency distributions of the diverse categories for the total of survey participants (third column) show that the whole set of participants it is dominated by males, people with academic degrees in the natural sciences, university researchers (mostly tenured, and with more than 10 years of experience) or university students, and residents in North America. It is also dominated by people who are not familiar with theories of interdisciplinary work, but think that theoretical discussions about interdisciplinary work are important.

Table 4-5 also indicates frequencies of the diverse categories within each group (second column for 'Group tendency no synonyms', and third column for 'Group tendency synonyms'), which describe each group and allow the examination of each group in contrast to the other. Table 4-6 summarizes results of the comparative description of the two groups. As shown in Tables 4-5 and 4-6, the group that tends not to see the terminology for interdisciplinary work as synonymous ('Group tendency no synonyms'), as compared to the group that tends to see the terminology as synonyms ('Group tendency synonyms'), includes a higher proportion of females, and people with academic degrees in the social sciences, the humanities, or a combination of social sciences, natural sciences and/or humanities, and a lower proportion of males and people with academic degrees in the natural sciences. It also contains higher percentages of university researchers or students, and private company employees, NGO employees or resource managers, and lower percentages of non-university researchers or government employees. Fewer university researchers in this group are tenured and more of them have less than five or between five and ten years of experience, as opposed to more than 10 years. Regarding location of participants, the 'Group tendency no synonyms' includes higher proportions of people residing in Europe

and countries outside Europe and North America, and lesser proportions of people residing in North America.

Whereas the ‘Group tendency no synonyms’ as compared to the ‘Group tendency synonyms’ is characterized by higher portions of people that are familiar with theories of interdisciplinary work, and people that are not familiar with theories and have not heard of them, it is also characterized by fewer people not familiar with theories but who have heard of them. Finally, this group has higher proportions of respondents that think theories of interdisciplinary work are important.

4.3.3. Characteristics determining differences in the definition

Table 4-5 also includes results from the crosstabulation analysis of the categories and respondents’ group membership. Results from the Chi-square test show that among all differences detected between ‘Group tendency no synonyms’ and ‘Group tendency synonyms’ only the difference regarding familiarity with theories of interdisciplinary work is statistically significant (p-value < 0.05). This category, therefore, is related to distinct interpretations of the concept of interdisciplinary work among the two groups of respondents.

A logistic regression analysis clarifies the degree to which this variable explains that people tend to make a distinction between interdisciplinary and other terms or tend not to make such distinction (see Table 4-7). Although the resulting regression model has poor quality (Nagelkelke R^2=0.068), it still correctly predicts respondents’ membership in 55% of cases. The model indicates that a respondent familiar with theories of interdisciplinary research and knowing these theories quite well is 4 times more likely to belong to the ‘Group tendency no synonyms’ (as compared to the ‘Group tendency synonyms’) than a respondent not familiar with them. Familiarity with theories of interdisciplinary work therefore, importantly determines whether or not people tend to make a distinction between the different terms for interdisciplinary work.

4.4. Discussion

EM is an inherently interdisciplinary field, and EM researchers increasingly engage with interdisciplinary practice. However, throughout the EM literature it is not clear how researchers in general think of interdisciplinary work. Results from this study indicate that they differ on the terminology they tend to use to refer to interdisciplinary research, but share an understanding about what it is. Findings further suggest that whereas interdisciplinary work is under-theorized in the field, there is a genesis of a group of ‘like-minded researchers’ that engage with theoretical discussions about interdisciplinary work. Implications of these findings are discussed in the context of the current state of development of the EM field and the advancement of its contributions to solving environmental problems.

4.4.1. Interdisciplinary work: The definition

This study finds that EM researchers identify interdisciplinary work is as a "way to do research" and a "way of thinking about research" to solve a problem at hand. This definition matches the definition proposed by some authors in the broader area of ecological sciences (di Castri & Hadley, 1985; Moss, 2000; Winder, 2003; Bruce et al., 2004; Tress, et al., 2004; Max-Neef, 2005). It also corresponds to the definition proposed in other practice-oriented fields (Klein, 1990; Klein, 1996; Salter & Hearn, 1996; Lattuca, 2001).

Researchers in practice-oriented fields such as EM, environmental planning, risk assessment or public health (Gibbons et al., 1994) use the interdisciplinary approach to conduct research and address specific problems (di Castri & Hadley, 1985). Interdisciplinary work in these fields is primarily defined as a means and not an end in itself (Klein, 1990; Klein, 1996; Salter & Hearn, 1996; Lattuca, 2001; Barry at al., 2008). Contrasting to definitions in the social sciences and humanities (Lattuca, 2001; Moran, 2002), in practice-oriented fields the concept does do not explicitly include critiques of the disciplinary structure of knowledge. However, although not explicitly, researchers in these fields also criticize and challenge disciplinarity when acknowledging the importance of linking disciplines to address real problems (Heberlein, 1988; Redclift, 1998; Gallopin, Funtowicz et al., 2001; Westley & Miller, 2003; Jasanoff, 2004), and when recognizing the limitations of scientific knowledge to effectively inform decisions (Gibbons et al., 1994; Folke, 2004; Jasanoff, 2004; Barry et al., 2008; Mehl-Madrona, 2009).

Results suggest that the concept of interdisciplinary work found here has points of convergence with the concept of transdisciplinary work as defined by the European transdisciplinary movement (Hirsch Hadorn, 2008). EM researchers do not tend to employ the term 'transdisciplinary' more than other terms such as 'pluri-' , 'cross-', 'multi-' or 'interdisciplinary', nor do they usually make special mention of the European transdisciplinary approach (Pujadas Botey & Garvin, 2010). These facts suggest that EM researchers are not affiliated with the European movement, and that they might not even be familiar with it. However, interdisciplinary work described as a research effort involving actors inside and outside academia in order to solve particular problems is in accord with the concept of transdisciplinary research as explicated by the European school (Tress et al., 2004; Hirsch Hadorn, 2008). It is interesting to notice that the inclusion of non-academics is not exclusive to the European transdisciplinary concept. There are other academic groups such as North American researchers in integrative studies that even though they do not stress non-academics' participation so much, do not exclude it either (Klein, 2008).

The European movement proposes transdisciplinary work as a form of research that is driven by the need to solve real problems. Transdisciplinary research tries to overcome the mismatch between knowledge requests for solving societal problems on the one hand, and knowledge production in academia on the other. It

involves the integration of disciplinary knowledge as well as non-academic knowledge related to a certain discipline (Tress et al., 2004; Hirsch Hadorn, 2008). It combines collaborative work with academic interdisciplinary work. Collaborative and interdisciplinary work are intertwined by a continuous process where academics and non-academics learn from each other to produce and apply knowledge to solve a problem of common interest (di Castri & Hadley, 1985; Gray, 1989; Lee, 1993; Brunner & Clark, 1997; Westley & Miller, 2003; Keen et al., 2005; Keough & Blahna, 2006; Hirsch Hadorn, 2008). Non-academics such as government agencies, NGOs, private corporations, and local communities provide knowledge related to their particular understanding of the issue studied, as well as their own values (needs, preferences, and expectations) (Gray et al., 2001; Meffe et al., 2002; Keough & Blahna, 2006). Academics provide their own expert scientific knowledge about the issue studied and disciplinary knowledge produced from the information provided by non-academics (di Castri & Hadley, 1985; Clark & Dickson, 2003; Steel, et al., 2004; Hanssen et al., 2009).

Transdisciplinary frameworks influential to EM are, for example, post-normal science (Funtowicz & Ravetz, 1994), new production of knowledge (Gibbons et al., 1994), sustainability science (Kates et al., 2001), policy science (Clark, 2002), participatory action research (Chambers, 1983) and socio-ecological research (Berkes et al., 2003). They all advocate the need to incorporate collaborative approaches to research and the need for integrating insights from the disciplines. In the context of the need to do collaborative and integrative research, EM researchers define interdisciplinary work as a form of research that brings together academics and non-academics to address practical problems.

4.4.2. Interdisciplinary ecosystem management research is under-theorized

Findings suggest that the concept of interdisciplinary work is not widely discussed among researchers in the field of EM. This situation reflects a general situation in practice-oriented fields such as environmental studies (Bruce et al., 2004; Lele & Norgaard, 2005), animal welfare sciences (Lund et al., 2006), landscape ecology (Moss, 2000; Tress et al., 2004) or health sciences (Rosenfield, 1992; McCallin, 2001; Boon et al., 2004) where researchers have reported that terms to refer to interdisciplinary research are used interchangeably or inconsistently with widely varying meanings. Researchers in these fields have expressed the need for unifying understandings about the concept and have called for more discussions of it (Rosenfield, 1992; McCallin, 2001; Bruce et al., 2004; Max-Neef, 2005).

There are at least two reasons for the low general emphasis on theoretical discussions in EM and other practice-oriented fields. First, the use of interdisciplinary approaches is still relatively recent. It was not until the 1970s and 1980s that researchers in these fields started to work to integrate insights from the disciplines and promoted others to do the same (di Castri & Hadley, 1985; Rosenfield, 1992; Jakobsen et al., 2004; Naveh, 2005; Van Kerkhoff, 2005; Tress et al., 2007). The emergence of EM and other practice-oriented fields resulted

from the need for including interdisciplinary approaches with those of already established disciplines (Gibbons et al., 1994; Moran, 2002). The fact that these fields emerged from consolidated disciplines implied that groups of interdisciplinary scholars started by justifying their existence and gaining recognition in the broader academic community (Moss, 2000). The current situation of these fields is therefore likely still one of adjustment, with researchers engaged in ongoing debates to establish codes that orient academic activity in general, and interdisciplinary research activity in particular (Rip, 1997; Van Kerkhoff, 2005).

A second possible reason for the low interest in discussing interdisciplinary theories in EM and other practice-oriented fields is that calls for interdisciplinary work have been focused on the need to solve real problems. The answer to this need is not generally accompanied by discussions about theoretical issues (Gibbons et al., 1994; Moran, 2002; MacMynowski, 2007; Pujadas Botey & Garvin, 2010). The origins of fields such as EM or environmental studies, animal welfare sciences, landscape ecology, and health sciences, are located in the natural sciences (Rosenfield, 1992; Ascher, 1999; Nyhus et al., 2002; Lund et al., 2006). The field of EM in particular has historical roots in ecology (Grumbine, 1994), and EM research projects are generally led by natural scientists (Kennedy, 1991; Blockstein, 1999). As a result, EM and similar fields are dominated by philosophical, ontological, and epistemological preferences of natural science. These preferences involve instrumental approaches that favour research activity to solve problems (Redclift, 1998; Lele & Norgaard, 2005; Evely et al., 2008), as opposed to critical reflexivity and theoretical approaches to understanding research (Van De Ven & Johnson, 2006; MacMynowski, 2007).

4.4.3. The value of theoretical considerations: A network genesis

Despite the paucity of attention currently paid to theoretical discussions about interdisciplinary work in the EM field, findings of the present chapter suggest that researchers recognize a value in such discussions. Actually, 74% of respondents agreed that theoretical discussions about interdisciplinary work are important. Data further indicate that there is a tendency towards discriminating between specific terms used for interdisciplinary work. While most EM researchers see the different terms as synonymous, there is a group of researchers that are familiar with theories of interdisciplinary work and reflect distinctions between terms proposed outside EM in the interdisciplinary theory-oriented literature (Jantsch, 1972; Kockelmans, 1979; Klein, 1990).

The genesis of a group of ‘like-minded researchers’ involved in a deeper engagement with theoretical considerations regarding interdisciplinary work suggests that researchers in EM are starting to commit to a more reflective interdisciplinary practice. Discussions about what interdisciplinary research means, its purpose, what it entails for the field, and what its practical applications should look like encourage practitioners to be more thoughtful, critical, and reflexive about interdisciplinary practice (Rip, 1997; Clark et al., 2001; Clark, 2002; Szostak, 2002; Pickett et al., 2007). Critique and awareness about the

process provide a basis for advancing interdisciplinary practice. On the one hand, it enables EM collaborating researchers to share a sense of what they think of interdisciplinary practice, and lead research in a shared direction (Bammer, 2005; Brunner, 2006; MacMynowski, 2007). On the other hand, it allows researchers in general to understand, evaluate, and build upon other interdisciplinary research experiences (Szostak, 2002; Bammer, 2005; Brunner, 2006; Klein, 2008). Deeper engagements with theoretical discussions of interdisciplinary research therefore, are relevant for effective interdisciplinary research in EM, potentially advancing its future contributions to environmental problems.

4.5. Conclusions

Results of the questionnaire survey study suggest that in the field of EM there is a shared sense of what interdisciplinary research is. The definition of the concept as understood by EM researchers coincides with the European definition of transdisciplinary research (Hirsch Hadorn, 2008). Results further indicate that despite an agreed understanding about the term among researchers and the recognition of the value of theoretical discussions about interdisciplinary work, such discussions are not (yet) part of the mainstream research activity. Two possible reasons for that are the early stage of development of the field (Rip, 1997; Van Kerkhoff, 2005), and the current dominance of epistemological and ontological preferences of the natural sciences (Redclift, 1998; Lele & Norgaard, 2005). Lastly, results suggest there is a group of 'like-minded researchers' interested in theoretical discussions about interdisciplinary work. A broader engagement with theoretical debates in EM might mean more critique and awareness about interdisciplinary practice and more effective interdisciplinary practice (Bammer, 2005; Brunner, 2006). Additional research focused on interdisciplinary practice in the field and the views of researchers involved with interdisciplinary theory can make important contributions to the EM field. The objective of Chapter 5 is to get a more in-depth understanding of these two issues.

4.6. Tables and figures

4.6.1. Tables

Table 4-1. Interdisciplinary variables and categories

Description (variable name)	Categories
Terms synonyms with interdisciplinary (Synonyms)	Multidisciplinary Crossdisciplinary Transdisciplinary Pluridisciplinary
Definition of interdisciplinary work (Definition)	Is a research process for linking (integrating) information Is a philosophy or way of thinking about research Is a search for universal knowledge Is a discipline Is a critique against disciplinarity Is a social movement (ideology) Is a claim for political and social equity
Types of research related to interdisciplinary work (Related research)	Collaborative research Problem-solving research
Social actors involved in interdisciplinary work (Social actor)	Exclusively outside academia Exclusively in academia In and outside academia
Size of group doing interdisciplinary work (Group size)	More than 4 people From 2 to 4 people 1 person

Table 4-2. Personal and theory variables and categories

Description (variable name)	Categories
Personal characteristics	
Gender (Gender)	Female Male
Area of academic degree (Academic area)	Social science Humanities Mixed Natural sciences
Primary professional occupation (Job)	University researcher or student Private company employee, NGO employee, or resource manager Non-university researcher or government employee
University tenure* (Tenure)	Yes
Number of years working at the university* (Years)	<5 years 5-10 years >10 years
Country of residence (Location)	Europe Other North America (United States and Canada)
Relationship with theories of interdisciplinary work	
Familiarity with theories of interdisciplinary work (Familiarity)	Familiar, good knowledge Not familiar, not heard of them Not familiar, but heard of them
Importance of theoretical discussions about interdisciplinary work (Importance of theory)	Important Somewhat important Somewhat unimportant Unimportant

* Questions asked of university researchers only

Table 4-3. Agglomeration schedule

Number of groups	Analysis step	Dissimilarity coefficient in last step	Dissimilarity coefficient in this step	Difference between dissimilarity coefficients
106	1	0	0	0
105	2	0	0	0
…	…	…	…	…
6	101	180.448	190.829	10.381
5	102	190.829	201.779	10.95
4	103	201.779	214.108	12.329
3	104	214.108	226.71	12.602
2	105	226.71	247.778	**21.068**
1	106	247.778	275.178	**27.4**

High differences between dissimilarity coefficients are indicated in bond

Table 4-4. Frequency distributions and chi-squares for interdisciplinary categories

Variable and Categories	Group 1 (N=59)	Group 2 (N=48)	Total (N=107)	Significance χ^2	Significance p-value
Synonyms					
Multidisciplinary	17 (29%)	28 (58%)	45 (42%)	9.46	0.002 *
Crossdisciplinary	9 (15%)	45 (94%)	54 (50%)	65.24	0.000 *
Transdisciplinary	9 (15%)	27 (56%)	36 (34%)	19.92	0.000 *
Pluridisciplinary	1 (2%)	8 (17%)	9 (8%)	—	
Definition					
Is a research process	55 (93%)	41 (85%)	96 (90%)	1.75	0.186
Is a philosophy	38 (64%)	39 (81%)	77 (72%)	3.72	0.054
Is a search	7 (12%)	7 (15%)	14 (13%)	0.17	0.678
Is a discipline	6 (10%)	7 (15%)	13 (12%)	0.48	0.487
Is a critique	8 (14%)	3 (6%)	11 (10%)	—	—
Is a social movement	1(2%)	2 (4%)	3 (3%)	—	—
Is a claim	1 (2%)	1 (2%)	2 (2%)	—	—
Related research					
Collaborative	48 (81%)	42 (88%)	90 (84%)	0.75	0.387
Problem-solving	42 (71%)	36 (75%)	78 (73%)	0.19	0.659
Social actor					
Outside academia	0 (0%)	0 (0%)	0 (0%)	——	——
In academia	6 (10%)	0 (0%)	6 (6%)	—	—
In and outside academia	51 (86%)	48 (100%)	99 (93%)	—	—
Group size					
More than 4 people	48 (81%)	42 (88%)	90 (84%)	0.75	0.387
From 2 to 4 people	45 (76%)	42 (88%)	87 (81%)	2.20	0.138
1 person	23 (39%)	13 (27%)	36 (34%)	1.68	0.195

Frequency distributions indicate presence of categories

Multiple responses permitted per category; ‘don’t know’ and non-response options omitted

Degrees of freedom = 1

* Statistical significance with a p-value ≤ 0.05

— The low number of respondents with presence and/or absence of this category in Group 1 and/or Group 2 does not allow the correct performance of the Chi-square analysis (>20% of the expected cell counts is <5 or one or more expected cell count is <1; Moore 1995)

—— Chi-square analysis was not performed because the category is a constant

The interpretation of this table results in calling Group 1 ‘Group tendency no synonyms’ and Group 2 ‘Group tendency synonyms’

Table 4-5. Frequency distributions and chi-squares for personal and theory categories

Variable and Categories	'Group tendency no synonyms' (N=59)	'Group tendency synonyms' (N=48)	Total (N=107)	Significance χ^2	Significance p-value
Gender *(N=107)*					
Female	15 (25%)	7 (15%)	22 (21%)	1.90	0.168
Male	44 (75%)	40 (83%)	84 (79%)	1.20	0.273
Academic area *(N=107)*					
Social sciences	25 (42%)	18 (38%)	43 (40%)	0.26	0.609
Humanities	6 (10%)	0 (0%)	6 (6%)	—	—
Mixed	2 (3%)	1 (2%)	3 (3%)	—	—
Natural sciences	44 (75%)	40 (83%)	84 (79%)	1.20	0.273
Job *(N=107)*					
University researcher or student	32 (54%)	24 (50%)	56 (52%)	0.19	0.663
Private company employee, NGO employee, or resource manager	8 (14%)	4 (8%)	12 (11%)	0.73	0.394
Non-university researcher or government employee	17 (29%)	16 (33%)	33 (31%)	0.25	0.615
Tenure *(N=51)*					
Yes	20 (67%)	19 (90%)	39 (76%)	—	—
Years *(N=55)*					
<5 years	5 (16%)	1 (4%)	6 (11%)	—	—
5-10 years	8 (25%)	5 (22%)	13 (24%)	0.08	0.779
>10 years	17 (53%)	17 (74%)	34 (62%)	2.45	0.118
Location *(N=107)*					
Europe	15 (25%)	9 (19%)	24 (22%)	0.68	0.410
Other	11 (19%)	6 (13%)	17 (16%)	0.75	0.387
North America	33 (56%)	33 (69%)	66 (62%)	1.84	0.175
Familiarity *(N=105)*					
Familiar, good knowledge	12 (21%)	3 (6%)	15 (14%)	4.66	0.031*
Not familiar, not heard of them	20 (35%)	14 (29%)	34 (32%)	0.42	0.518
Not familiar, but heard of them	25 (44%)	27 (56%)	52 (50%)	1.60	0.206
Importance of theory *(N=107)*					
Important	24 (41%)	17 (35%)	41 (38%)	0.31	0.578
Somewhat important	21 (36%)	17 (35%)	38 (36%)	0.00	0.985
Somewhat unimportant	9 (15%)	8 (17%)	17 (16%)	0.04	0.842
Unimportant	1 (2%)	3 (6%)	4 (4%)	—	—

Frequency distributions indicate presence of categories

'Don't know' and non-response options omitted

Degrees of freedom = 1

* Statistical significance with a p-value ≤ 0.05

— The low number of respondents of presence and/or absence of this category in 'Group tendency no synonyms' and/or 'Group tendency synonyms' does not allow the correct performance of the Chi-square analysis (>20% of the expected cell counts is <5 or one or more expected cell count is <1; Moore, 1995)

Table 4-6. Summary of comparison between of groups

'Group tendency no synonyms'	'Group tendency synonyms'
Gender	
More females	Fewer females
Fewer males	More males
Academic area	
More degrees in the social sciences, humanities, and mixed	Fewer degrees in the social sciences, humanities, and mixed
Fewer degrees in the natural sciences	More degrees in the natural sciences
Job	
More university researchers or students	Fewer university researchers or students
More private company employees, NGO employees, or resources managers	Fewer private company employees, NGO employees, or resources managers
Fewer non-university researchers or government employees	More non-university researchers or government employees
(University researchers: fewer tenured and fewer with >10 years of experience)	(University researchers: more tenured and more with >10 years of experience)
Location	
More residents in Europe, and other	Fewer residents in Europe, and other
Fewer residents in North America	More residents in North America
Familiarity	
More familiar with theories of ID and good knowledge	Fewer familiarity with theories of ID and good knowledge
More not familiar with theories of ID and not heart of them	Fewer not familiar with theories of ID and not heart of them
Fewer not familiar with theories of ID but heart of them	More not familiar with theories of ID but heart of them
Importance of theory	
More theory is important	Fewer theory is important
Fewer theory is unimportant	More theory is unimportant

ID = Interdisciplinary work

Comparisons are in relative terms ('more' = 'higher proportions of', 'fewer' = 'lower proportions of')

Familiarity with theories of interdisciplinary work and good knowledge is the only statistically significant difference

Table 4-7. Categories associated with membership in 'Group tendency no synonyms'

Category	Wald χ^2	p-value	Odds ratio (95% CI)
Familiarity			
Familiar, good knowledge	4.593	0.032*	4.239 (1.131-15.884)

Reference category for group is 'Group tendency synonyms'

Model based on presence of the category 'familiarity, good knowledge' (as opposed to presence of 'not familiar', including those who heard of theories and those who did not)

CI = Correspondence Intervals

Model fit: χ^2= 5.616, df=1; p-value= 0.018*; Nagelkelke R^2=0.068
Overall percentage: 55.1%

* Statistical significance with a p-value ≤ 0.05

4.6.2. Figures

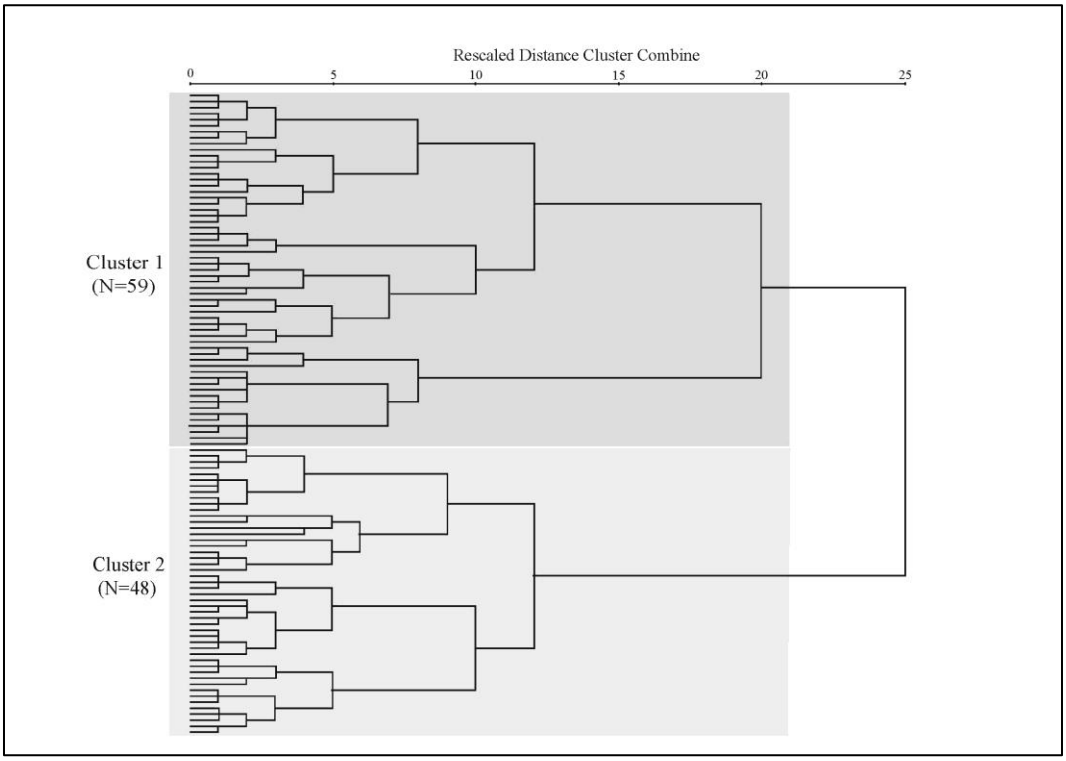

Figure 4-1. Dendogram. Clusters 1 and 2 represent the two distinct groups of respondents resulting from the analysis.

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CHAPTER 5

THE PRACTICE OF INTERDISCIPLINARITY
AN INTERVIEW STUDY

5.1. Introduction

This chapter examines perspectives about interdisciplinary practice among EM researchers by interviewing a targeted set of 15 researchers[10] who participated in the questionnaire used in the previous chapter (Chapter 4. Questionnaire Survey). It starts from the definition of interdisciplinary work evaluated in the Questionnaire Survey to analyse how interdisciplinary research is conducted in the EM field. It is tied to both Chapter 3 (Literature Evaluation) and Chapter 4 by providing a deeper discussion about the role of theoretical considerations regarding interdisciplinary research in EM.

5.2. Methods

The study used an interpretive research approach to explore the different ways EM researchers undertake and interpret interdisciplinary practice (Denzin & Lincoln, 2000; Creswell, 2003; Neuman, 2003; Creswell, 2007). This in-depth component of the larger project employed semi-structured interviews and interpretive coding as methods of collecting and analyzing data.

5.2.1. Data collection and analysis

Data were collected by employing semi-structured interviews (Kvale, 1996; Fontana & Frey, 2000; Seidman, 2006). The study analyzes the perspectives of 15 EM researchers. Potential interviewees were participants involved in the previous research stage (Chapter. Questionnaire Survey) who stated in the questionnaire they were willing to continue participating in the research project. From a set of 37 potential participants, interviewees were selected using a purposive maximum variation sampling model (Lincoln & Guba, 1985; Baxter & Eyles, 1997; Patton, 2002; Neuman, 2003; Tashakkori & Teddlie, 2003; Maxwell, 2005) to represent the different views about interdisciplinary work detected in previous stages of the project. According to prior results it was important to incorporate participants of varied academic backgrounds, with different degrees of familiarity with theories of interdisciplinary work, and with diverse opinions about the value of theoretical considerations regarding interdisciplinary activity in the field. People from both genders, with different professional occupations, and located in various geographic areas around the world were included. Main characteristics of participants are indicated in Table 5-1. Selected researchers were systematically contacted and interviewed until reaching the point of saturation, where no new information emerged (Lincoln & Guba, 1985; Patton, 2002).

[10] Certificates of ethics approval for this study are presented in Appendix 2.

The interviews covered three topics relevant to understanding the practice of interdisciplinary research in EM[11]: 1) interest in discussions about how researchers practice interdisciplinary work; 2) agreement on how interdisciplinary work is conducted; and, 3) activities describing the process of doing interdisciplinary work. Interviews were conducted between October and December 2009. They were administrated individually, by phone, and in English. They lasted between 30 and 90 minutes each. Interviews were electronically audiotape-recorded, transcribed verbatim, and sent to participants for review (Rubin & Rubin, 2005).

Data analysis consisted of systematically reviewing the interview transcripts to build an interpretive text that explains data collected (Miles & Huberman, 1994; Maxwell, 2005). NVivo software (version 8) for qualitative research assisted the analysis. The analysis is based on three key strategies: coding, memoing, and diagram drawing. Coding consists of orderly reviewing the transcripts to detect pieces of text related to ideas or topics that are important to the research problem, and assigning them codes (or labels) (Miles & Huberman, 1994; Charmaz, 2000; Rubin & Rubin, 2005). Recognizing that the researcher doing the analysis is a research instrument[12] (Lincoln & Guba, 1985; Creswell, 2007), codes were determined following an inductive rather than deductive process (Charmaz, 2000). Codes included descriptions of what was happening in the data (descriptive codes), interpretations and reflections on what might be occurring in the data (analytical codes), and groupings of already defined codes (pattern or inferential codes) (Miles & Huberman, 1994).

Memoing is the second strategy of analysis employed. It is the process of writing memos (or notes) that are meaningful for the researcher during the coding process. Memos can be explanations about the codes, and ideas about the importance of certain codes or relations between the codes (Birks et al., 2008). The third strategy used is diagram drawing. From the constant comparison of pieces of text assigned under the different codes, relationships between codes and patterns in data are detected and represented in diagrams. Diagrams act as summarizing tools in that they help put together and make sense of data resulting in the emergence of interpretive texts around data (Miles & Huberman, 1994).

Quality of data and findings (i.e. rigour, *sensu* Baxter & Eyles, 1997) were ensured by four different measures. First, when collecting data the researcher took field notes to help interpret the data (Lincoln & Guba, 1985a; Miles & Huberman, 1994; Maxwell, 2005). Second, she asked participants to clarify ambiguous responses, and gave them the opportunity to check accuracy and add or remove anything from the transcription of their interview (Miles & Huberman, 1994;

[11] This list refers to the interview topics used in the analysis presented in this chapter. For a complete list of topics included in the interview see the interview guide, which is presented in Appendix 4.

[12] A reflection on the researcher positionality is presented in Appendix 5.

Maxwell, 2005). Third, once data were collected, two additional researchers audited the analysis process, and assessed the interpretation and codification of texts (Dey, 1993; Baxter & Eyles, 1997). Fourth, results are presented in detailed and thick writing (Miles & Huberman, 1994; Baxter & Eyles, 1997).

5.3. Results

One major finding emerged from the data. EM researchers have two different perspectives about the practice of interdisciplinary research. While the majority of researchers indicate interdisciplinary research is mainly an intuitive process, a minority indicates it is mainly a reflexive process. This finding resulted from three main points arisen in the interviews. First, there is not a widespread interest in having deep discussions about how interdisciplinary research is conducted. Second, EM researchers do not agree on how to do interdisciplinary work. Finally, the range of perspectives about interdisciplinary practice delineates the process as a set of activities in three interrelated phases: establishment of the research agenda and interdisciplinary team; integration of the insights from the disciplines; and, research implementation. Although respondents agree on these general steps, they disagree about the relative importance of intuition and critical reflexivity of the researcher when conducting interdisciplinary work.

5.3.1. Interdisciplinary practice: Intuition *versus* reflection

Research interviews showed two different and apparently conflicting ways of doing interdisciplinary work: intuition-based and reflection-based. Most respondents agree with the first perspective, while some agree with the second one. Researchers in the two distinct perspectives present differences regarding their familiarity with theories of interdisciplinary work, which is not surprising given the fact that this characteristic was already related to different understandings about interdisciplinary work in Chapters 3 (Literature Evaluation) and 4 (Questionnaire Survey).

Respondents both familiar and not familiar with theories of interdisciplinary work agree with the majority perspective, where interdisciplinary practice is seen an intuitive process:

> *You often find people talking about what are the essential good features of good practices in such and such scenarios, or what is critical to get it right, etc. etc. (…) From my point of view, the ideals of a discipline like ecosystem management are practical. They are not only practical, but it's centrally about practice. And effective practice, is not centrally about explanation. (…) If you are trying to do transdisciplinary [interdisciplinary] work, then, you must be open to following the leading of the situation.* (Dr. Sis[13], familiar with theories of interdisciplinary work)

Respondents mostly familiar with theories of interdisciplinary work, agree with the minority perspective, where interdisciplinary practice is seen as a necessarily reflexive process:

[13] Names used are pseudonyms.

I would probably make the case that some people think that intuitively they would do it. But in fact, they only do part of it. If you are not conscious of what you are doing, how can you be sure you are being interdisciplinary? So, one has to be conscious enough of your knowledge and skills to know what you are doing, and also what you are not doing. And also to be comparative of what you are doing against what others propose that interdisciplinary work is. However, there are some people who intuitively are doing good things, but they are also incomplete. It is like a brain surgeon, you know? A brain surgeon has to be explicitly systematic and totally knowledgeable of the surgical techniques in order to be a professional. So, in order to be interdisciplinary, really interdisciplinary, you need to be knowledgeable of what you are doing. You don't want to have a brain surgeon who is intuitive. You want somebody to exactly explain what they are going to do and why. So, you can evaluate what they are doing. (Dr. Grimm, familiar with theories of interdisciplinary work)

The division of participants in viewing the interdisciplinary process as mainly guided by intuition or mainly guided by reflection was evident throughout the interviews, as presented in the following sections.

5.3.2. Low interest in discussions about the process

Respondents recognized that in the field of EM there is little general interest in reflecting on how interdisciplinary work is conducted. Some respondents stated that such discussions are not a priority among EM researchers and that as a result, they are barely present in the field.

They [EM researchers] are more worried about doing their part and not discussing really what they actually do. (Dr. Cleo, not familiar with theories of interdisciplinary work)

It is not uncommon to mention the need for some kind of inter-transdisciplinary work, et cetera. Not always much more than saying that, but it is there. (Dr. Eduardo, familiar with theories of interdisciplinary work)

Some respondents stated there actually is certain interest in discussions about the interdisciplinary process, and these discussions do take place in EM. However, they clarified that these discussions are held at the level of practice rather than at theoretical and methodological levels.

I can't imagine them not talking about it. You know, if you have people on a team, they are discussing who they are, what they are doing. I don't think that talks are about deep methodological theory, but they talk. I suspect it's more of a conversation about frustrations and overcoming frustrations. (Dr. Lee, familiar with theories of interdisciplinary work)

I would argue they do discuss, the answer to your question is yes. But when they discuss it is usually through story. It is not through examination. It is through the experiences in practice. It is through stories.

And stories are helpful, but they are not adequate to distillate the principals of interdisciplinary work so these can be talked about explicitly. (Dr. Grimm, familiar with theories of interdisciplinary work)

According to participants, there is a limited interest among EM researchers in discussing the interdisciplinary process, especially in considering theoretical and methodological aspects of the research practice. This finding suggests that researchers in the EM field may reflect on the process, but they mostly see it as intuition-driven.

5.3.3. No agreement on the process

Participants recognized that there is not complete agreement on how to do interdisciplinary work in EM. Some participants emphasized there are no rules or specific agreed instructions that direct how the process must be carried out or what is allowed when practicing interdisciplinary work.

I certainly do not follow any preconceived rule. I usually just make it up as it goes along. It's not until somebody like you start asking these questions, that I stop to reflect on what works. Like I said, the research is usually curiosity driven and, when a cool question comes on mind, that's what drives it. (Dr. McGregor, not familiar with theories of interdisciplinary work)

It is something that in practice keeps emerging all the time. So, it's not like an accepted way of doing it. (Dr. Kham, familiar with theories of interdisciplinary work)

Participants highlighted the importance of not having preconceived ideas about how to act, and allowing the interdisciplinary process to continuously emerge and constantly adapt to the context of the problem studied.

I would say that I think there is a whole spectrum out there on how people think that interdisciplinary work should be done. Yes… yes, I don't think there is an agreed way, and I think a lot of it is very 'try it and see'. (Dr. Mingus, not familiar with theories of interdisciplinary work)

Now, what I am saying happens that way in every project? No. Am I saying it is the only way of doing it? No. it really depends on what kind of problem you are finding. A lot of this reflects my own experience, what kind of problems I am interested in. (…) It depends on who the actors are, and who they should be, and what is going on. (Dr. Fire, familiar with theories of interdisciplinary work)

Most participants however, consider that despite the fact that there is not a single, shared way of doing interdisciplinary work, there is a certain concurrence on how practitioners generally act. Particularly, they refer to 'standards' or 'protocols' such as organizing workshops and encouraging informal conversations, which enhance communication between participants from different disciplines.

> *There are some standards. A lot of people agree [on them], and a lot of people do not agree [on them], but they are known as accepted standards.* (Dr. Grimm, familiar with theories of interdisciplinary work)

Interdisciplinary work is introduced as a way of doing research that does not follow particular directions, but mainly emerges as the process is conducted. Once again, discussions about the process are not suggested to be a research priority among EM researchers, and the process is explained as adapted to the particular situation studied, and mainly guided by researchers' intuition.

5.3.4. Interdisciplinary research as a three phase process

The interdisciplinary process was presented by participants as a research team exercise where academics from different disciplines and people outside academia collaborate to integrate information from more than one discipline and solve a particular problem at hand. Integration is perceived as the main point of the interdisciplinary process. Respondents' view of the process can be explained by a flexible sequence of activities revolving around integration, and articulating three phases. Phase 1 prepares for integration by setting the research agenda and establishing interaction between participants. Phase 2 integrates across disciplines. Phase 3 results from integration by implementing the research. Descriptions about the process mainly refer to Phase 2, and pay less attention to Phases 1 and 3. However, interviewees emphasize the three phases are closely interrelated and cannot easily be separated. The three are part of an adaptive management cycle where research is conducted and iteratively implemented to solve the problem. Until satisfactory results are achieved, research is conducted and continuously provides information to be used in the implementation of the research through managerial decisions. Research implementation at the same time leads to new information about the problem that informs further research efforts.

5.3.4.1. Phase 1: Preparation for integration

Prior to integration, an interdisciplinary research project consists of a series of activities aimed at framing the research agenda. These activities ideally involve decisions made under consensus by everybody included in the project.

> *I think it is very useful and also very efficient to involve people from different disciplines in framing the research questions or framing the research agenda, and thinking through not only what kind of research needs to be done, but what is going to be done with the data (…). So, I think it is very useful to have people from different disciplines involved in the planning of the research and the planning of the analysis of findings. (…). That, unfortunately, is not always the case. And rarely is the case that you'll have the opportunity to kind of organically plan. In the end, projects are multidisciplinary in nature. I think often they tend to be… Disciplines that are critical tend to be brought late in the game*. (Dr. Cleo, not familiar with theories of interdisciplinary work)

The formation of an interdisciplinary team is a key activity of the interdisciplinary research process. The researcher or group of researchers who initiate the study

determine who will be part of the team. The team includes academics with expertise in the particular disciplines, as well as actors outside academia who have knowledge and interests related to the problem at hand.

> *I contacted a few individuals that I know have been involved in the prior work. Then we discussed what can be done with the funds that are available, and what other funds can be available. (…) Then we looked at who can do that work. We tried to figure out who the experts would be, and bring them on board. And then they expanded further again into the network of people that they know.* (Dr. Cleo, not familiar with theories of interdisciplinary work)

> *You think about the aspects you can use to answer the question, and assemble the team. And sometimes there are players that are very intelligent, but they are individuals that are impossible to work with. And that is part of that too; it's that human aspect. I think I would rather leave them out consciously, that is my personal opinion, and have something that works well together and that delivers something that is useful, than to build the perfect team on paper, but is unfunctional.* (Dr. Puig, not familiar with theories of interdisciplinary work)

> *I think what happens is that you often get approached by someone in an NGO or people themselves , who say: help. And people from universities are supposed to help. So, then maybe, ok, let's get together. We got sort of what you… come out with a problem as something outside academia. We had a brief initial discussion defining who is on the team, who may not be. And then you go back to those individuals and have a much wider discussion. (…) You have a much wider discussion with others who might be interested in being involved in the process too.* (Dr. Fire, familiar with theories of interdisciplinary work)

Once the team is established, participants jointly contribute to framing the research agenda. Firstly, they delineate the research problem to be dealt with, and subsequently, based on the problem, they define the research objective. Other activities relevant to setting the agenda, although mentioned to a much lesser degree among respondents, were: defining the research methodology and methods, analyzing the academic background information available on the particular research question, and determining how the study findings will be communicated to society for the implementation of the research.

5.3.4.2. Phase 2: Integration

Integration was referred to by all participants as the essence of any interdisciplinary exercise. It is defined as:

> *People working outside their discipline, building bridges, incorporating ideas from other disciplines fully into what they are doing. (…) People bringing what they know to the table and then talking with other people about what other people know, and then trying to reach a common ground*

between the two. (Dr. Solis, familiar with theories of interdisciplinary work)

However, some participants found it difficult to detail specific activities that describe integration, suggesting that the interdisciplinary process occurs spontaneously as the research is being conducted, and that it is not something they commonly discuss.

You interact with people as you would do in any sphere of life. It just happens… You know, you are talking of ideas, instead of buying bread or some other interaction… I am not sure how best to explain… a lot of interaction happens through narratives, whether there is in the sciences or outside. So, in a sense you are writing stories about your work, and pulling people into these stories, and finding shared narratives. (Dr. Solis, familiar with theories of interdisciplinary work)

Despite the difficulties in detailing particular activities of the integration process, respondents referred to necessary and helpful elements for successful integration, as summarized in Figure 5-1. These elements give hints about the different activities for achieving integration and how they take place. The most mentioned necessary element is commitment of all collaborators to interdisciplinary research.

It is important to avoid the perception of tokenism or the perception that a social scientist for instance is invited to participate only because the donor wants it or because it is the politically correct thing to do these days… Really recognizing the critical importance of working across disciplines and to make sure that they… that the human side is not given too little attention in what we do. (…) Without a very serious engagement of social scientists (…), it just does not work. (Dr. Cleo, not familiar with theories of interdisciplinary work)

With scientists at least, we all have similar goals, and we have egos,… But part of this assembling is if we are willing to have this openness to understanding, and trying to figure out what people's perspectives are. (Dr. Puig, not familiar with theories of interdisciplinary work)

Building up trust I think is very important. So, I think trust, openness, willingness to work things through (…) are the key ingredients (Dr. Solis, familiar with theories of interdisciplinary work)

Another important element for successful integration is contextualization of the research. Research aimed at solving real problems has to be constantly adapted to the changing reality that frames problems.

One of the key things is staying problem-focused. So, really try to come to solve the problem. (…) You won't know everything. So, I think you have to come out with an agenda to start with, but you certainly also have to be very sensitive to the fact that your agenda might not fit the reality of the situation (…). So, I think it is a very recursive process, very much back

and forth. (…). You are adapting because you are realizing that that is going to work. (Dr. Fire, familiar with theories of interdisciplinary work)

I would say that arguably the biggest problem is the separation between the academic and practical in this area, resource and environmental management. It is a challenge. Most students don't get much field experience. They don't spend much time in understanding how things really work in the real world. Understanding that is a big part of being effective, you know, in the ground of ecosystem management and achieving interdisciplinarity. (Dr. Eduardo, familiar with theories of interdisciplinary work)

Expertise is another element that respondents consider leads to integration. Respondents mentioned that both expertise in the disciplines and expertise in doing interdisciplinary work are required. They referred to skills and knowledge gained when conducting research, as well as skills and knowledge acquired by training.

Researchers who are employed on such projects should bring their own ideas and expertise to the 'shell' of the research project (…). At the end of the day, the research that you do has to be of good quality. So, people have to know what they are doing in the different disciplines. (Dr. Mingus, not familiar with theories of interdisciplinary work)

I think that you go through your career before you start to be aware of what things are gonna work, who you work with, who you probably cannot work with, all sorts of things. So, I think that the experience is critical to make it function. (Dr. Gaston, not familiar with theories of interdisciplinary work)

For people who are more likely to work in very interactive situations, or do very interdisciplinary work, I think there needs to be some sort of thought given to programs to train people in some skills with this common background from an early stage of the university education (…). It [better training] is something that would help. It is a case of giving people a better training in some of these methods, and also providing them with learning opportunities through courses where people are more forced to workshop things, do group-work, deal with difficult people. These sorts of things I think help a lot in terms of the products that come out of these courses. (Dr. Solis, familiar with theories of interdisciplinary work)

To a lesser degree, respondents talked about the importance of having some kind of guideline for integration. They indicated the value of having an explicit research framework that describes a set of research assumptions to be shared by people across the disciplines involved.

There are maybe 15 or 20 different management frameworks that have been proposed for different processes around problem-solving in a

collective situation. And there is quite a high variation in what these things suggest. And obviously, they all have useful elements.(…) Soft Systems Methodology, for instance, has gone through different stages (…) as they've adapted it to different situations. (…) Elinor Ostrom has a bunch of frameworks. There are things like adaptive management that ecologists use. And there are things like De Beer's Team Syntegrity. (Dr. Solis, familiar with theories of interdisciplinary work)

Some respondents also mentioned that specific research techniques might assist in the integration of information.

Simulation models can force you to integrate information from different disciplines in order to build models. And I think that similarly GIS and environmental information systems can be useful too. (…) GIS and information systems help try to organize material. (Dr. Eduardo, familiar with theories of interdisciplinary work)

Few respondents talked about elements that facilitate integration by enhancing effective interactions between people involved in the interdisciplinary effort. In this regard they emphasized the importance of informal conversations among all participants and during the whole research process. They also mentioned the importance of establishing common language, having team leadership, and favouring good personal relationships within groups.

5.3.4.3. Phase 3: Result of integration

All participants see that the process of doing interdisciplinary work does not finish with integration across disciplines, but continues through the implementation of the research findings. This part of the research, however, was little detailed among respondents. All comments made regarding implementation were related to the need to communicate research findings to actors such as ecosystem managers or policy-makers, who make decisions regarding the environment.

What defines a good interdisciplinary experience? Well, if it resolves something, and if it is translated into action, in terms of the knowledge that is generated being is relevant enough to the society that uses it. (Dr. Magda, familiar with theories of interdisciplinary work)

5.4. Discussion

The present study suggests that in the EM field there are two main perspectives about interdisciplinary practice. The two perspectives differ on the kind of knowledge they emphasize for guiding interdisciplinary practice. While one emphasizes implicit knowledge (intuition), the other highlights explicit knowledge (reflection, and a resulting organized set of concepts and methods). The first perspective is represented by researchers both familiar and not familiar with theories of interdisciplinary work, and the second one by researchers primarily familiar with theories of interdisciplinary work. Separated from the field of EM, in fields such as integrative studies, where researchers study interdisciplinary work (Chubin at al., 1986; Klein, 2000; Repko, 2008), there is a

third perspective about the interdisciplinary process. This perspective also recognizes the importance of explicit knowledge in orienting interdisciplinary work (see Chapter 2).

The three perspectives share the idea of the interdisciplinary process as an exercise in which insights from different disciplines are integrated. However, they differ on the degree of detail they provide about integration. As suggested by the findings, in the context of EM integration is under-explored. In the literature of theoretical fields, by contrast, integration is highly detailed (Klein, 1990; Szostak, 2002a; Newell, 2007; Repko, 2008). Using the analogy of the 'black box' (Belevitch, 1962), integration in the three perspectives is explained as an intermediate between clear inputs (disciplines) and a clear output (understanding of the interdisciplinary problem). As indicated in Figure 5-2, discussions in EM that emphasize implicit knowledge about interdisciplinary practice are represented by a black box, where details about the integration process are not visible. Discussions in EM that highlight explicit knowledge are represented by a semi-transparent box, where certain details about the integration process are suggested. Finally, discussions in the theoretical literature also stressing explicit knowledge are represented by a transparent (or quasi-transparent) box, where lots of details about the integration process are explicated.

5.4.1. Interdisciplinary work in the black box

The black box in Figure 5-2 represents the perspective where clarifications about the integration process are, in fact, unnecessary. In this case, no explanation about transformations between disciplines and interdisciplinary understanding of the problem needs to be specified. Implicit or felt knowledge about the situation addressed, expressed as 'intuition', 'wisdom', 'talent' or 'artistry' (Schön, 1987; Walkerden, 2009), suffices to give a reason for integration. This perspective is expressed by researchers in EM who are familiar as well as those who are not familiar with theories of interdisciplinary work.

Researchers in this perspective assert that human actions are deliberate, decided, and willed by individuals or groups (Checkland & Scholes, 1990). Actions are guided by knowledge that is acquired in an iterative learning process, where individuals and groups act, interpret their actions, reflect on them, learn from them, and consequently act (Lee, 1993; Brunner & Clark, 1997; Westley & Miller, 2003; Keen et al., 2005). These researchers argue that since the world is complex, and any decision on a real situation implies too numerous considerations to think through explicitly, our implicit knowledge about the situation is what most importantly guides effective action (Walkerden, 2005). Implicit knowledge about the situation is what we inherently know about the situation as a whole, what we feel about it, the sense we make of it (Rivett, 1983; Schön, 1987; Walkerden, 2005; Walkerden, 2009). Resulting from experimental models of 'learning-by-doing', implicit knowledge results in an evolving sense of the situation that entails richness and creativity in actions (Schön, 1987; Walkerden, 2009). Applied to integration, this evolving sense of the situation contributes to

solving the problem by ensuring that interdisciplinary practice is applied to the things that are relevant to the situation framing the problem.

The fact that implicit knowledge is uniquely suited to the situation studied and to each individual involved in the research process does not mean that working from implicit knowledge is something that automatically happens as the research is being conducted. Indeed, there are abilities that can be taught and learnt for effectively working from implicit knowledge (Walkerden, 2005). Results indicate that only some proponents of this perspective, who are familiar with theories of interdisciplinary work, might be knowledgeable and even take a part in such discussions, suggesting considerations regarding the process of working from implicit knowledge are not among the main research interests of EM researchers. However, results also indicate that researchers in general talk about problems to be faced when doing interdisciplinarity research, indicating they largely think there might be common solutions to these problems.

5.4.2. Interdisciplinary work in the semi-transparent box

The semi-transparent box in Figure 5-2 represents the perspective where explicit explanations about how integration takes place matter and are in fact important for guiding practice. This perspective is expressed by EM researchers who admit familiarity with theories of interdisciplinary work.

Researchers in this perspective emphasize the capacity of individuals for self-reflection and learning-by-doing in an iterative process of action-reflection (Keen et al., 2005). They also recognize the complexity of the world, and the limitations of our abilities to appreciate complexity (Schön, 1987; Brunner, 2006). Similar to the previous perspective, the challenge of understanding the complex reality is met by an ideally never-ending process, where actions are taken, and in the light of their results are evaluated, and constantly adjusted for subsequent applications (di Castri & Hadley, 1985; Checkland & Scholes, 1990; Brunner & Clark, 1997). The two perspectives, however, differ on the way lessons from practice are expressed and applied to further practice. As opposed to the previous perspective, under this perspective lessons are made explicit and translated into a set of theoretical considerations (models, concepts) and methods (research instruments and techniques) that pragmatically orient the interdisciplinary exercise. The fact that researchers in this perspective are mostly familiar with theories of interdisciplinary work, as indicated by the results in the present study, suggests that theoretical considerations and methods proposed by individual researchers are part of a wider disagreement over how to conduct interdisciplinary work.

Researchers in the semi-transparent box perspective place integration in the broader context of collaborative research (Gray, 1989; Lee, 1993; Keough & Blahna, 2006), defined as work going beyond academic disciplines. Coinciding with the definition of ‘transdisciplinary research’ proposed by the European movement (Hirsch Hadorn, 2008), interdisciplinary work here is understood as crossing both disciplinary boundaries and sectors of society. As discussed in Chapter 4 (Questionnaire Survey), under the European concept of

transdisciplinary research academic actors as well as actors outside academia such as government agencies, local communities, or NGOs are included in this version of the interdisciplinary research effort.

In the context of collaborative research, researchers explain interdisciplinary work by adopting some of the approaches developed in different practice-oriented areas for dealing with problems that cross disciplinary and social domains (di Castri & Hadley, 1985; Bammer, 2005). Under approaches such as systems thinking and complexity sciences (Bertalanffy, 1968; Capra, 1997; Gunderson & Holling, 2002), participatory research (Gray, 1989; Fisher et al., 1991; Lee, 1993; Keough & Blahna, 2006; Wallerstein & Duran, 2008), knowledge management and policy sciences (Ostrom, 1999; Clark, 2002; Reich & Reich, 2006; Senge, 2006) researchers articulate theories and methods for doing interdisciplinary work and addressing particular real-world problems.

In this perspective the integration stage is not detailed. Information about how to operationalize integration is primarily suggested by the specific tools researchers propose for facilitating the overall interdisciplinary (or transdisciplinary) research process. In particular, they emphasize theoretical considerations such as selection of key disciplines and participants, commitment of participants to the interdisciplinary effort, incorporation and reconciliation of social information and values, and adaptability to the changing context (di Castri & Hadley, 1985; Clark et al., 2000; Stevenson et al., 2001; Clark, 2002; Lele & Norgaard, 2005; Reich & Reich, 2006; Walkerden, 2006). They also include specific methods for guiding interdisciplinary practice like case studies, prototyping (or field-testing innovative models), policy exercises, decision seminars (Brunner & Clark, 1997; Clark, 1999; Clark, 2002; Brunner, 2006), simulation computer models, and geographic information systems (Robinson & Mackay, 1995; Biggs et al., 2000; Antle et al., 2001; Walkerden, 2006).

5.4.3. Interdisciplinary work in the transparent box

The transparent box in Figure 5-2 symbolizes discussions currently taking place outside the EM field, where explanations about the integration process are important for guiding interdisciplinary practice.

Researchers in this perspective study interdisciplinary work in theoretical fields of integrative studies. They provide exhaustive explanations about the concept and its practice. Similar to the two previous perspectives, here interdisciplinary work is presented as a process of drawing on relevant disciplines and involving the integration of their insights to produce an interdisciplinary understanding about the problem addressed. Disciplinary insights are specific arguments about the phenomenon studied in a discipline that represent a cognitive advancement about it (Szostak, 2003; Repko, 2008). They are obtained using a specific set of theories, methods, and perspectives that are agreed and accepted by the academic community within a particular discipline (Klein, 1990; Klein, 1996; Salter & Hearn, 1996; Szostak, 2003; Repko, 2008). In an interdisciplinary exercise,

disciplinary insights are combined in order to produce integrated knowledge related to the problem.

Differing from researchers in the previous perspectives, researchers in this perspective identify key processes and propose explicit and systematic procedures for clarifying decisions regarding the operationalization of the integration stage. Procedures for integrating disciplines as presented by Klein (1990), Szostak (2002), Newell (2007) and Repko (2008) can be summarized in three main steps:

> **Step 1**. It identifies conflicts in disciplinary insights relevant to studying the problem. Conflicts in disciplinary insights are the focus of creating common ground, a fundamental component of integration (Newell, 2007). For identifying conflicts, theories, methods, and perspectives related to each relevant discipline are detected and constantly compared and contrasted to these same elements related to every other discipline. Typologies of disciplinary elements (such as the one presented in Szostak, 2004) might be helpful in this task.
>
> **Step 2**. It generates common ground between disciplinary insights. It modifies disciplinary elements identified in the previous step to create elements that bring common meaning among disciplines and therefore act as integrators between them. There are five different techniques useful for this purpose: theory expansion, redefinition, extension, organization, and transformation to modify disciplinary theories, methods, and perspectives (Repko, 2008).
>
> **Step 3**. It integrates disciplinary insights to produce an interdisciplinary insight. The integration of disciplinary insights involves the combination of conflicting insights detected in Step 1 by using the common ground theories, methods, and perspectives created in Step 2. Just as disciplinary elements lead to producing disciplinary insights, common ground elements lead to producing integrated insights. Resulting integrated insights represent a cognitive advancement or interdisciplinary understanding about the problem.

As revealed by this description, theoreticians deeply examine the integration process and proclaim it to be a challenging task that demands close attention to the different steps.

5.4.4. Contributions

Discussions about the interdisciplinary process are fundamental for advancing interdisciplinary practice in fields such as EM. They provide practical and analytical tools for doing interdisciplinary research. On the one hand, they reveal both difficulties and opportunities for action in the research process. On the other hand, they enable self-reflection, and informed and conscious decisions about the research process (Clark et al., 2001; Clark, 2002; Szostak, 2002b). Discussions about the process, in addition to providing tools for conducting research, help to clarify the interdisciplinary process. They allow researchers to understand similarities and differences on how they understand and conduct the process, and

facilitate evaluations about the diverse research efforts conducted under interdisciplinary approaches, enabling more effective advances in interdisciplinary practices (Szostak, 2002b; Bammer, 2005; Brunner, 2006; Pohl et al., 2008).

The particular views about the interdisciplinary process manifested in the three perspectives identified in this chapter present additional elements useful for advancing interdisciplinary practice in the field of EM. Specifically, the emphasis they put on implicit and explicit knowledge, and the explanations they provide about integration contribute interesting elements for discussing how interdisciplinary work is or could be conducted in EM.

5.4.4.1. Implicit and explicit knowledge

The three perspectives highlight differently the importance of implicit and explicit knowledge about the interdisciplinary process for guiding practice. Far from being contradictory, implicit and explicit knowledge complement each other. Implicit knowledge provides the basis for creative thinking. As in any research process, it plays a role in interdisciplinary practice. However, if not accompanied by consciousness and rationality about the research process, it might bias research decisions towards subconscious perceptions and desires (Szostak, 2002b; Szostak, 2004). Being self-aware of the process is at least a partial antidote for personal bias that may skew integration. It thus helps to prepare researchers' minds for creative thinking and effectively contributes to interdisciplinary understanding of the problem (Repko, 2008).

However, explicit knowledge about the process also plays a role in interdisciplinary practice. It provides the basis for conscious thinking, and facilitates critical analysis about how to proceed in practice (Clark et al., 2001; Clark, 2002; Szostak, 2002b). However, by itself it does not guarantee adequate interdisciplinary efforts. The interdisciplinary research process is not strictly an intuition-based procedure; neither is it a strictly linear, step-based procedure, rigidly following particular theoretical considerations or specific methods. Both intuition and explicit knowledge take part in guiding decisions about the process (Newell, 2007; Repko, 2008).

5.4.4.2. Integration and Ecosystem Management collaborative research

Perspectives about the interdisciplinary process in EM and theoretical fields present different degrees of detail about the process of integrating disciplinary insights. While in theoretical fields the integration process is highly detailed in a step-wise process, in EM it is not directly explained. Theoretical fields provide specific procedures to direct conscious decisions regarding the integration of the insights from different disciplines. EM provides particular explanations about interdisciplinary collaborative research at a smaller scale with elements useful for implementing the integration process as described in theoretical fields.

Particularly, directions from theoretical fields guide how to identify conflicts in relevant disciplinary insights, how to create common ground, and how to integrate

disciplinary insights to produce interdisciplinary insights. Elements from EM such as the importance of selecting key disciplines and participants, having researchers' commitment to the interdisciplinary exercise, incorporating and reconciling their views and interests, and acknowledging adaptability, help to frame the integration process. EM also provides specific tools such as case studies, decision seminars, or simulation computer models, which are appropriate for facilitating the different steps of the integration process.

The theoretical and the EM perspectives present inputs into the integration process that are complementary. As concluded in Chapter 4 (Questionnaire Survey) some EM researchers might be starting to engage with theoretical discussions taking place in integrative studies, a fact that suggests the two separated discussions in EM and in theoretical fields might find convergence. The cross-fertilization of inputs from the two discussions is crucial for the EM field since it would enable a more complete picture of what a more effective interdisciplinary EM research could look like. Researchers in EM are advancing interdisciplinary practice by emphasizing collaboration, but they could use developments in theoretical fields to further advance interdisciplinary practice as a whole. EM researchers could, for example, learn specific procedures for determining disciplines relevant to the problem addressed, and for comparing and contrasting these disciplines to take the most of them. Given the importance of cross-fertilizations between discussions in EM and theoretical fields, it becomes relevant to direct future research towards understanding the major obstacles for conversations across the two academic communities, and the elements that would promote such conversations.

5.5. Conclusions

Results from this study indicate that discussions about how interdisciplinary work is conducted are not considered an important part of mainstream research activity in EM, but are nonetheless present. Discussions among EM researchers take place in the context of collaborative results, and acknowledge the role of both implicit and explicit knowledge. Discussions in separate theoretical fields focus on academic integration of insights from various disciplines and provide explicit and detailed knowledge about this process. The work reported here discusses the main points of methodological discussions inside and outside EM to encourage further debates on EM's interdisciplinary practice and its effective contribution to environmental problems.

5.6. Tables and figures

5.6.1. Tables

Table 5-1. Characteristics of participants

Interview number	Academic background	Familiarity with theories	Value of theory	Gender	Job*	Geographic location
1	Mixed	Yes	Yes	Female	1	North America
2	Natural sciences	No	Yes	Male	1	Europe
3	Natural sciences	No	No	Male	1	North America
4	Natural sciences	Yes	No	Male	1	North America
5	Natural sciences	No	Yes	Female	3	North America
6	Mixed	Yes	Yes	Female	1	Africa
7	Natural sciences	Yes	Yes	Male	1	North America
8	Natural sciences	No	Yes	Male	2	Africa
9	Natural sciences	No	Yes	Male	2	North America
10	Natural sciences	No	Yes	Female	3	North America
11	Mixed	Yes	Yes	Male	1	Africa
12	Natural sciences	No	Yes	Male	2	North America
13	Mixed	Yes	Yes	Male	1	Oceania
14	Social sciences	Yes	Yes	Male	1	North America
15	Social sciences	Yes	Yes	Female	1	Europe

Mixed = any combination of social sciences, natural sciences, and humanities

* Jobs included are: 1 = University researcher, 2 = Non-university researcher or government employee, 3 = Private company or NGO employee

5.6.2. Figures

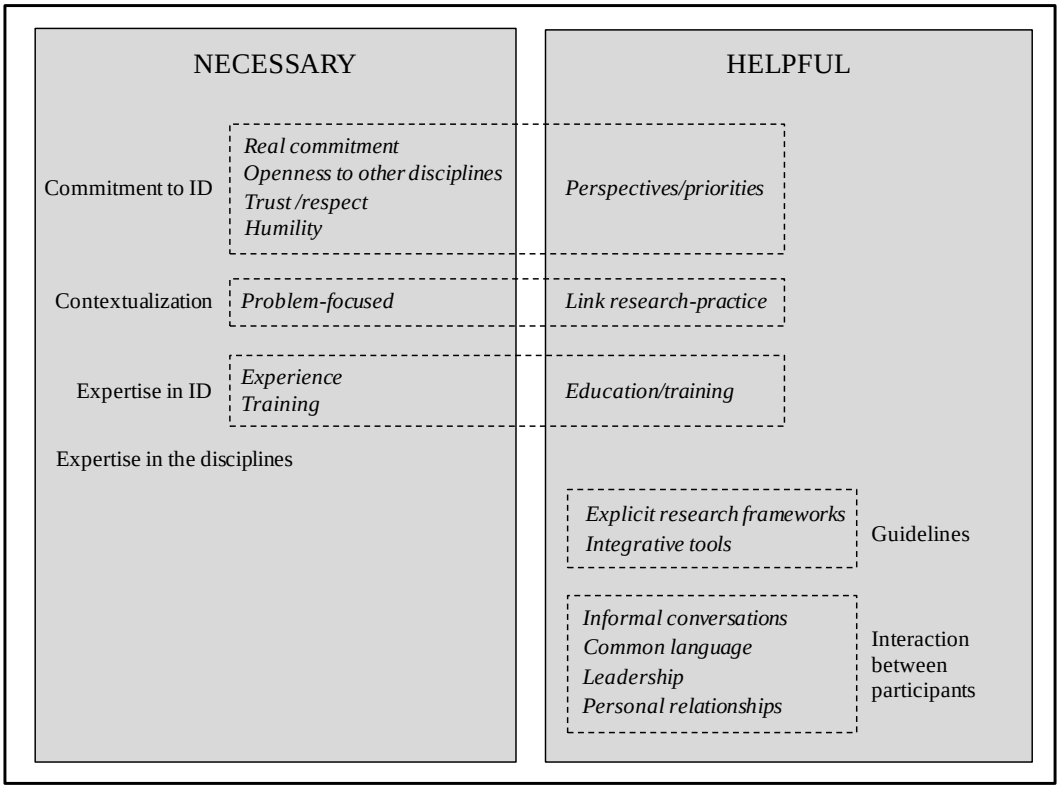

Figure 5-1. Elements of the interdisciplinary process. Elements are integrated by codes (i.e. ideas, presented in italics) indicating features that are necessary and features that are helpful for the interdisciplinary process. Elements, and codes within each element, are represented in a vertical order according to the importance given by respondents.

ID = Interdisciplinary work

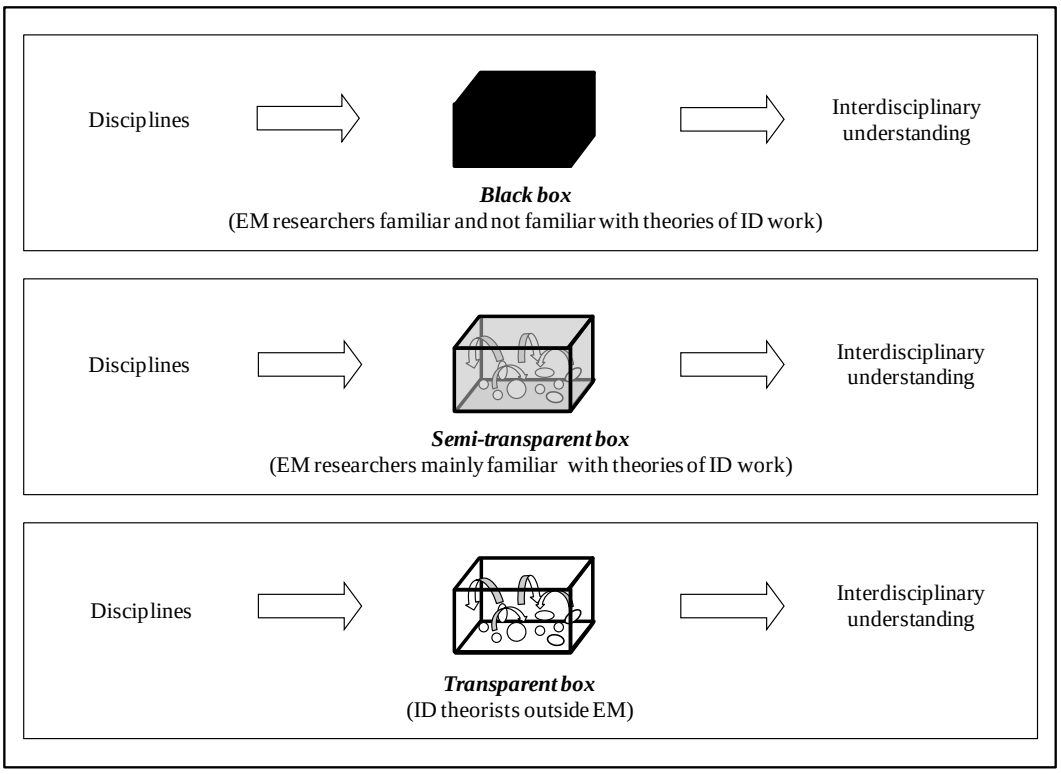

Figure 5-2. Different perspectives on integration. Using the analogy of the "black box", the three perspectives represented are: black box, semi-transparent box, and transparent box.

ID = Interdisciplinary work

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CHAPTER 6

CONCLUSION

6.1. Introduction

The study presented in this dissertation analyses ecosystem management (EM) researchers' perspectives and practices regarding interdisciplinary work. First, it presents the concepts of interdisciplinary and EM research and links them to each other (Chapter 2. Background). Second, it evaluates patterns in the use of terminology for interdisciplinary work in the EM literature (Chapter 3. Literature Evaluation). Third, it explores the definition of interdisciplinary work among a set of EM researchers (Chapter 4. Questionnaire Survey). Finally, it examines the process of conducting interdisciplinary work among a set of EM researchers (Chapter 5. Interview Survey). Taken together, these chapters situate EM in the broader context of interdisciplinary research in science, and advance EM interdisciplinary research efforts towards solving environmental problems.

6.2. Research contributions

The chapters in this dissertation make methodological, theoretical, and substantive contributions. Methodologically, this research provides an example of mixed-methods research and explores the practical relevance of using a pragmatist approach. Theoretically, it advances academic understanding of what interdisciplinary research is and how it is considered and practiced in the field of EM. Substantively, it contributes practical elements valuable to effective interdisciplinary EM research in solving environmental problems. Since EM adopts an adaptive management approach, where research and its applications in real-world situations are closely related (Holling, 1978; Lee, 1993; Walters, 2001), theoretical and substantive contributions are strongly tied to each other.

6.2.1. Methodological contributions

The pragmatist research approach emerged in the 1980s as a framework alternative to the two dominating paradigms traditionally presented as opposed: positivism/post-positivism and constructivism/interpretivism (Tashakkori & Teddlie, 2003; Tashakkori & Teddlie, 1998; Denzin & Lincoln, 2000; Creswell, 2003). Although it is seen by many scientists as a valid research approach (Cherryholmes, 1992; Creswell, 2007), it is not universally accepted within the academic community (Feilzer, 2010; Teddlie & Tashakkori, 2009).

The study presented in this dissertation shows that pragmatism can serve as a rationale for conducting formal academic work by following a mixed-methods research design. It combines bibliometric and statistical analysis (Chapter 3. Literature Evaluation) with closed-ended questionnaires and statistical analysis (Chapter 4. Questionnaire Survey) and semi-structured interviews and interpretive coding (Chapter 5. Interview Study) in order to achieve particular research objectives and fulfill the overall research goal. By acknowledging the value of

both quantitative and qualitative research methods, and using them in a legitimate way the research makes clear the validity and appropriateness of the pragmatist approach.

6.2.2. Theoretical contributions

EM is a field that addresses broad issues and demands interdisciplinary work (Daily & Ehrlich, 1999; Redman, 1999; Wear, 1999; Eigenbrode et al., 2007; Blockstein, 1999). However, researchers in EM have shown relatively little interest in researching how interdisciplinary work is considered, defined and practiced in their field.

The present work contributes to filling this gap in the EM literature by studying how EM researchers include interdisciplinary research in their academic work, and how they think of and pursue interdisciplinary research. Chapter 3 (Literature Evaluation) concludes that a minority of EM works mention interdisciplinary research, and engage with theoretical discussions about the concept. Chapter 3 also finds that institutional, language and philosophical factors likely to discourage EM researchers from advancing theoretical considerations regarding interdisciplinary activity in the field.

Chapter 4 (Questionnaire Survey) finds that EM researchers use different terminologies for interdisciplinary work, but share a common understanding of what it is. They define interdisciplinary work as both a "way to do research" and a "way of thinking about research." This chapter suggests that some EM researchers have a growing interest in developing deeper engagements with theoretical discussions about interdisciplinary research taking place outside their own field.

Finally, Chapter 5 (Interview Study) indicates that critical reflexivity about how interdisciplinary work is conducted is of general interest, but is not dominant in the EM field. Such discussions can and do take place in the context of collaborative research but do not include explicit descriptions of the process of integrating disciplinary insights. Discussions taking place outside the field complement current discussions in EM by providing detailed procedures guiding an informed and conscious interdisciplinary practice.

The information arising from the chapters in this dissertation contributes to discussions starting to take place in EM literature. In particular, it points out the value of interdisciplinary research, and provides particular elements useful for responding to the pressing need to effectively conduct interdisciplinary research for solving environmental problems.

This research can also potentially contribute beyond the EM field. This statement, however, must be taken with caution. This research is a case study, and as such, it is context-specific and aims at depth and detail in the inquiry (Stake, 2000; Yin, 2009). It focuses on the perspectives and practices of interdisciplinary work in EM. It does not intend to provide generalizations applicable in other contexts, and

it is not generalizable to other contexts (Creswell, 2007). This does not mean, however, that elements of the research are not transferable to other situations that have elements in common with the case studied here (Baxter & Eyles, 1997). As such, the research might contribute in two different contexts. First, it might contribute insights to other interdisciplinary, practice-oriented fields such as landscape ecology, risk assessment, or public health, which follow similar development paths (Gibbons et al., 1994; Rip, 1997; Moran, 2002). Second, the research might be helpful to fields such as integrative studies addressing interdisciplinary work. By providing an example of interdisciplinary practice and illustrating what happens in interdisciplinary work's everyday practice, this study potentially contributes to the advancement of theories of interdisciplinary work.

6.2.3. Substantive contributions

EM is an academic field that is particularly promising for solving environmental problems (Grumbine, 1994; Pickett & Ostfeld, 1995; Christensen et al., 1996), but its success depends in great part on the effective performance of collaborative interdisciplinary research and its results in adequately understanding socio-ecological systems (Gray, 1989; Lee, 1993; Berkes, Colding, & Folke, 2003; Norton, 1992; Costanza, Wainger, Folke, & Maler, 1993).

The present study contributes to EM participations in solving environmental problems by providing EM researchers with insights into the academic discussion, which are presented in the theoretical contribution section.

6.3. Study challenges and limitations

For every research project there are challenges and limitations, and the project presented in this dissertation is no exception. As such, there are two main challenges and two main limitations associated with this study. The challenges are related to methodology and to the interdisciplinary nature of the research. The limitations are related to theoretical and substantive research contributions.

First, an important challenge is related to the fact that the study as a dissertation research is mainly conducted by a single researcher, and to the fact that it uses quantitative and qualitative research methods. Although it is increasingly not the case any more (in disciplines such as geography), one typically does not find both quantitative and qualitative research methods in the same academic curriculum. As a result, researchers are rarely trained in or acquire equal skills in both research traditions. Therefore, this multi-method study represents an interesting research challenge.

Second, another relevant challenge refers to the interdisciplinary nature of the study. The study ties together the fields of interdisciplinary and EM research, which do not use common research philosophical assumptions, theories, methods or rules. Understanding current discussions taking place in the two separate fields and bringing them together is thus a challenging research endeavour.

Third, there are limits of what the research can achieve by studying EM researchers' perspectives and practices concerning interdisciplinary work. For practical reasons and the need for a specific objective, the work chooses to focus exclusively on the views of EM researchers, and more particularly on those researchers publishing in international, English language, peer-reviewed journal articles related to EM and interdisciplinary work. The study could make greater contributions to the EM field and its advance to environmental problems by including other researchers and other actors also involved in doing and implementing interdisciplinary EM research.

The research presents a final research limitation by remaining restricted to the EM field. As stated in the research contribution section, by expanding the study focus to other practice-oriented fields, it could have more important contributions to interdisciplinary science.

6.4. Future research directions

Future research could take a number of directions. Decisions about future research can be made based on findings and conclusions of the study. They can also be founded on contributions and limitations of the study. Findings and conclusions indicate one clear research path. Contributions and limitations indicate at least two possible ways to go.

Findings and conclusions from this study indicate the need for promoting deeper theoretical discussions about interdisciplinary research in the field of EM. More particularly, they suggest there is a growing interest in developing more in-depth discussions, and outline the importance of promoting greater conversations among EM researchers and researchers in other fields, especially those theorizing interdisciplinary practice. For advancing in this direction, favourable future research focuses on better understanding the challenges, barriers and openings for a greater presence of such discussions in EM. Debates regarding the current position of EM researchers concerning theoretical discussions would help to visualize the costs and benefits of having such discussions, and encourage researchers to think about taking some action.

Contributions and limitations of the study recommend the extension of the present research to go beyond the views of EM researchers publishing in international, English language, peer-reviewed journals. Founded on this recommendation, future research would include more researchers in EM and a greater number of actors relevant for doing and applying EM research. Studies in this direction would provide a more complete picture of EM's current situation regarding interdisciplinary work, and a wider view of the opportunities and challenges for EM's contributions to solving environmental problems.

Finally, a second research path suggested by contributions and limitations would go beyond EM as a case study. It could include views about interdisciplinary work in other practice-oriented fields. From assessing previous research carried

out in these other fields regarding perspectives on interdisciplinary work, or conducting in other fields studies similar to the one conducted here, EM could be better situated in the broader context of interdisciplinary work in science. Such studies could make important contributions to the field of EM and its interdisciplinary practice, and at the same time be more useful to both other practice-oriented fields and fields addressing theories of interdisciplinary work.

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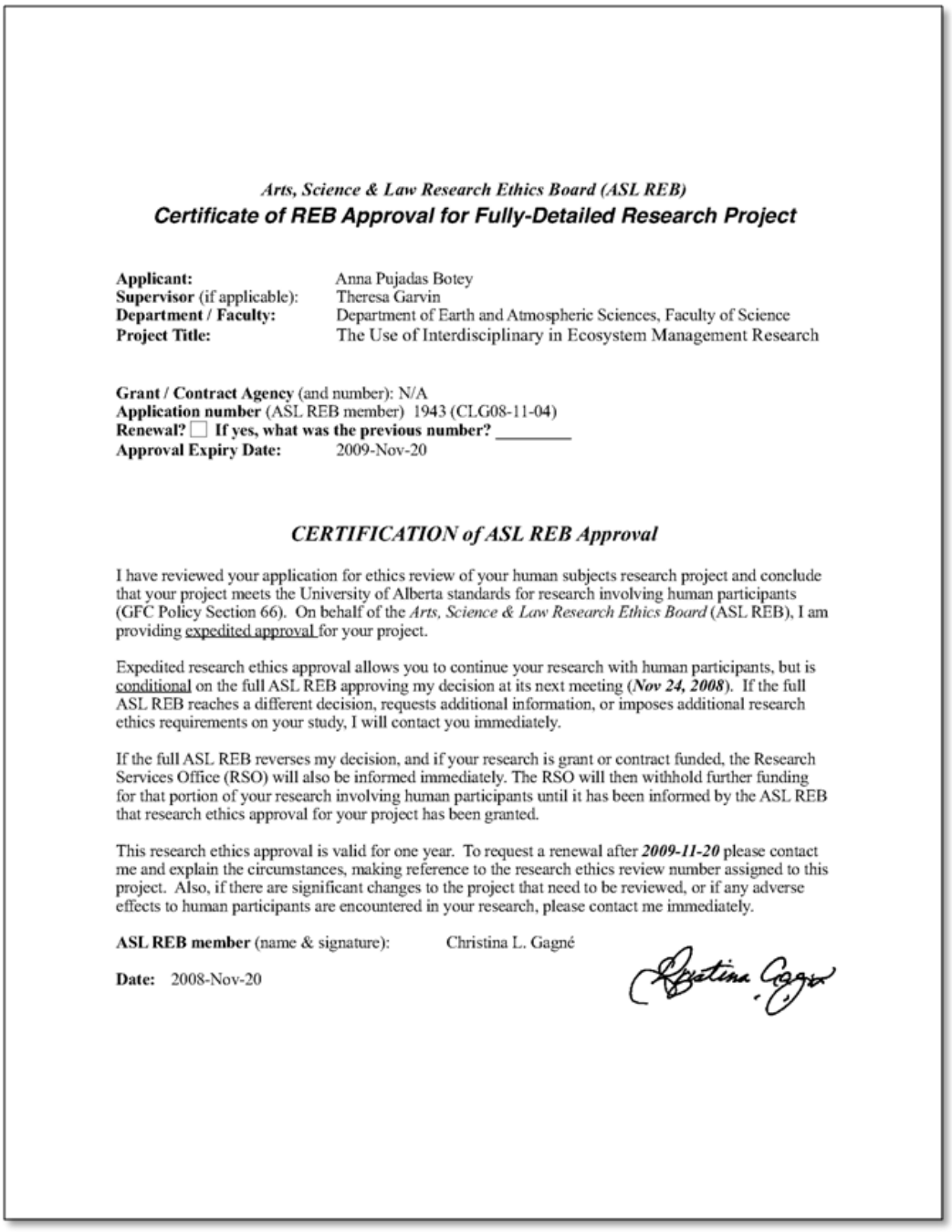
Appendix 2. Certificates of ethics approval



Arts, Science & Law Research Ethics Board (ASL REB)

Certificate of REB Approval for Fully-Detailed Research Project

Applicant: Anna Pujadas Botey
Supervisor (if applicable): Theresa Garvin
Department / Faculty: Department of Earth and Atmospheric Sciences, Faculty of Science
Project Title: The Use of Interdisciplinary in Ecosystem Management Research

Grant / Contract Agency (and number): N/A
Application number (ASL REB member) 1943 (CLG08-11-04)
Renewal? ☐ **If yes, what was the previous number?** _____
Approval Expiry Date: 2009-Nov-20

CERTIFICATION of ASL REB Approval

I have reviewed your application for ethics review of your human subjects research project and conclude that your project meets the University of Alberta standards for research involving human participants (GFC Policy Section 66). On behalf of the *Arts, Science & Law Research Ethics Board* (ASL REB), I am providing expedited approval for your project.

Expedited research ethics approval allows you to continue your research with human participants, but is conditional on the full ASL REB approving my decision at its next meeting (***Nov 24, 2008***). If the full ASL REB reaches a different decision, requests additional information, or imposes additional research ethics requirements on your study, I will contact you immediately.

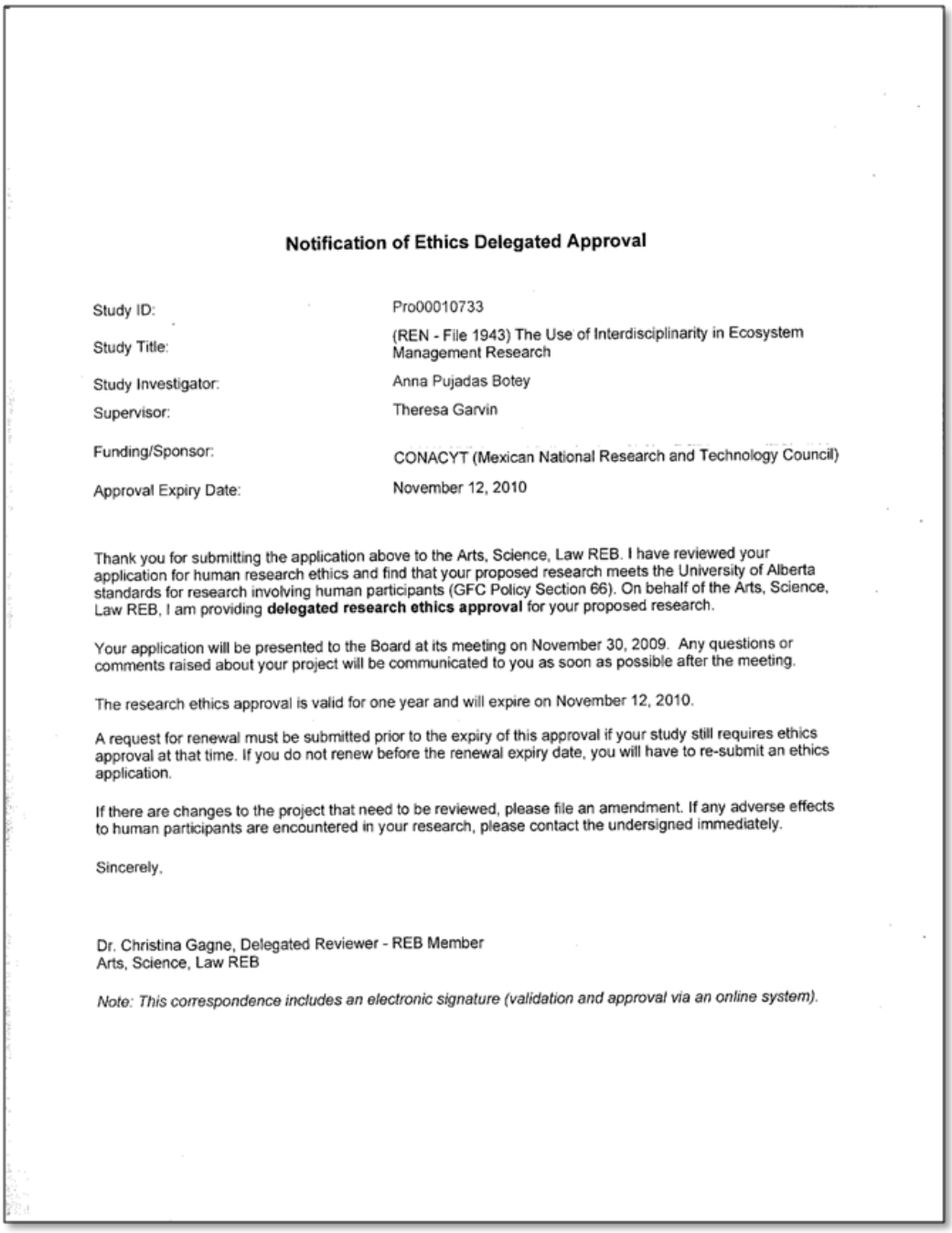
If the full ASL REB reverses my decision, and if your research is grant or contract funded, the Research Services Office (RSO) will also be informed immediately. The RSO will then withhold further funding for that portion of your research involving human participants until it has been informed by the ASL REB that research ethics approval for your project has been granted.

This research ethics approval is valid for one year. To request a renewal after ***2009-11-20*** please contact me and explain the circumstances, making reference to the research ethics review number assigned to this project. Also, if there are significant changes to the project that need to be reviewed, or if any adverse effects to human participants are encountered in your research, please contact me immediately.

ASL REB member (name & signature): Christina L. Gagné

Date: 2008-Nov-20

Ethics approval, November 2008



Notification of Ethics Delegated Approval

Study ID:	Pro00010733
Study Title:	(REN - File 1943) The Use of Interdisciplinarity in Ecosystem Management Research
Study Investigator:	Anna Pujadas Botey
Supervisor:	Theresa Garvin
Funding/Sponsor:	CONACYT (Mexican National Research and Technology Council)
Approval Expiry Date:	November 12, 2010

Thank you for submitting the application above to the Arts, Science, Law REB. I have reviewed your application for human research ethics and find that your proposed research meets the University of Alberta standards for research involving human participants (GFC Policy Section 66). On behalf of the Arts, Science, Law REB, I am providing **delegated research ethics approval** for your proposed research.

Your application will be presented to the Board at its meeting on November 30, 2009. Any questions or comments raised about your project will be communicated to you as soon as possible after the meeting.

The research ethics approval is valid for one year and will expire on November 12, 2010.

A request for renewal must be submitted prior to the expiry of this approval if your study still requires ethics approval at that time. If you do not renew before the renewal expiry date, you will have to re-submit an ethics application.

If there are changes to the project that need to be reviewed, please file an amendment. If any adverse effects to human participants are encountered in your research, please contact the undersigned immediately.

Sincerely,

Dr. Christina Gagne, Delegated Reviewer - REB Member
Arts, Science, Law REB

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Ethics approval (renewal), November 2010

Appendix 3. Questionnaire format

(Note: Fields that are required to be filled out are marked with *)

Thank you for your interest in the study "The Use of Interdisciplinarity in Ecosystem Management Research"

Your participation in this project is voluntary. All your information is confidential and anonymous.

By filling out this questionnaire you are helping me collect data for my PhD thesis at the University of Alberta, Canada. Results will provide insights useful to the ecosystem management academic community in its ongoing effort to develop and enhance interdisciplinary work in the context of environmental deterioration.

If you have any questions during or after the study, please contact us at:

Anna Pujadas Botey (PhD student) — (1) 780 492 5880 — pujadasb@ualberta.ca

Theresa Garvin (research supervisor) — (1) 780-492-4593 — Theresa.garvin@ualberta.ca

Department of Earth and Atmospheric Sciences
University of Alberta
Edmonton, Alberta, Canada

Please check the box below if you would like to continue with this survey.

○ I willingly consent to taking this survey

The following questions ask your opinions about doing interdisciplinary work

---

1. To start, please provide your own definition of interdisciplinary work.

2. In your opinion, interdisciplinary work is:
[Please check all that apply]

- o A process for linking (integrating) information
- o A discipline with its own set of theories and methods
- o A philosophy or way of thinking about the research process
- o A social movement (ideology)
- o A search for universal knowledge
- o A critique against disciplinarity
- o A claim for political and social equity

o Don't know
o Other

(The next question appears if answer to question 2 is "a process for linking (integrating) information")

3. In your opinion, interdisciplinary work links:

	Yes	No	Don't know
Academic interests, information, data, results	o	o	o
Academic knowledge, theories and concepts	o	o	o
Academic methods, procedures and tools	o	o	o

(The next question appears if answer to question 2 is "a process for linking (integrating) information")

o It (also) links other elements such as:

4. Are any of the following terms synonymous with interdisciplinary?

	Yes	No	Don't know
Multidisciplinary	o	o	o
Pluridisciplinary	o	o	o
Crossdisciplinary	o	o	o
Transdisciplinary	o	o	o
A closer synonym is:			

5. To what extend is interdisciplinary work related to the following categories of academic research?

	Strongly related	Somewhat related	Somewhat unrelated	Strongly unrelated	Don't know
Collaborative research	o	o	o	o	o
Problem-solving research	o	o	o	o	o
Team research	o	o	o	o	o

6. Where is interdisciplinary work conducted?
- o Both inside and outside academia
- o Exclusively inside academia
- o Exclusively outside academia
- o Don't know

7. What size of group does interdisciplinary work?
[Please check all that apply]

o 1 person
o From 2 to 4 people
o More than 4 people
o Don't know

8. How many ecosystem management researchers do you think share your own definition of interdisciplinary work?

Almost all of them	Most of them	Some of them	None of them	Don't know
o	o	o	o	o

9. There are currently a set of theories from philosophy and sociology of science that define interdisciplinary research and its practice. Are you familiar with these theories?

- o Yes, I know these theories quite well
- o Yes, I have heard of them, but I am not really familiar with them
- o No, I have not heard of them
- o Don't know

10. How often do you think ecosystem management researchers discuss the theory of interdisciplinary work?

Very often	Often	Sometimes	Never	Don't know
o	o	o	o	o

(The next question appears if answer to question 10 is "very often", "often" or "sometimes")

11. Where do these discussions of the theory of interdisciplinary work take place? [Please check all that apply]

- o In peer-reviewed articles published in natural science journals
- o In peer-reviewed articles published in social science journals
- o In book chapters
- o In grant proposals
- o In academic meetings
- o In specialized workshops
- o In informal conversations
- o Don't know
- o In other forums

12. How important do you think it is to discuss theory of interdisciplinary work in ecosystem management? *

Important	Somewhat important	Somewhat unimportant	Unimportant	Don't know
o	o	o	o	o

(The next question appears if answer to question 12 is "important" or "somewhat important")

Why are these discussions of theory important?

(The next question appears if answer to question 12 is "somewhat unimportant" or "unimportant")

Why are these discussions of theory not important?

13. How often do ecosystem management researchers discuss the practice of interdisciplinary work?

Very often	Often	Sometimes	Never	Don't know
o	o	o	o	o

(The next question appears if answer to question 13 is "very often", "often" or "sometimes")

14. Where do ecosystem management researchers discuss the practice of interdisciplinary work?

[Please check all that apply]

- o In peer-reviewed articles published in natural science journals
- o In peer-reviewed articles published in social science journals
- o In book chapters
- o In grant proposals
- o In academic meetings
- o In specialized workshops
- o In informal conversations
- o Don't know
- o In other forums

15. How important do you think it is to discuss the practice of interdisciplinary work in ecosystem management? *

Important	Somewhat important	Somewhat unimportant	Unimportant	Don't know
o	o	o	o	o

(The next question appears if answer to question 15 is "important" or "somewhat important")

Why are these discussions of practice of interdisciplinary work important?

(The next question appears if answer to question 15 is "somewhat unimportant" or "unimportant")

Why are these discussions of practice of interdisciplinary work not important?

16. There are many ways of doing interdisciplinary work. Which of the following are used by ecosystem management researchers? *
[Please check all that apply]

- o Just do it - interdisciplinary work is intuitive and everything works out in the end
- o Follow a pre-established strategy and research plan
- o Consult experienced peers in ecosystem management to get advice
- o Read about other experiences in ecosystem management
- o Consult experienced peers in other fields to get advice
- o Read about other experiences in other fields
- o Consult experts in interdisciplinary theory and practice
- o Don't know
- o Another way

(The next question appears if answer to question 16 is "consult experienced peers in other fields to get advice" or "read about other experiences in other fields")

17. What fields do they consult?

18. Would you say ecosystem management is an interdisciplinary field? *
o Yes o No o Don't know

19. In your opinion, what percentage of ecosystem management researchers use interdisciplinary approaches?
o 0-25% o 26-50% o 51-75% o 76-100% o Don't know

20. Ecosystem management includes: *
[Please check all that apply]

- o The natural sciences
- o The social sciences
- o Don't know
- o Other

(The next question appears if the answer to question 20 includes "the social sciences")

21. The main contributors to ecosystem management research are:

- o The natural sciences (the social sciences play a secondary role)
- o The social sciences (the natural sciences play a secondary role)

- o The natural and the social sciences play an equally important role
- o Don't know

(The next question appears if the answer to question 20 includes "the social sciences")

22. In ecosystem management research, the social sciences are important:
[Please check all that apply]
- o In understanding ecosystems and their management
- o In dealing with people and politics to implement research
- o Don't know
- o Other [ ]

In order to contextualize the findings, please tell us a little about yourself

---

23. In which of the following groups would you place your primary job?
- o University researcher (or postgraduate fellow, research assistant)
- o University student
- o Government employee
- o Private company/agency employee
- o Nongovernmental organization employee
- o Natural resource manager
- o Other [ ]

(The next question appears if answer to question 23 is "university researcher (*or postgraduate fellow, research assistant)")*

24. Are you tenured?
o Yes o No

(The next question appears if answer to question 23 is "university researcher (or postgraduate fellow, research assistant)")

25. How long have you been working at the university?
o Less than 5 years o From 5 to 10 years o More than 10 years

26. What is your gender?
o Male o Female o Other

27. The institution in which you are currently affiliated is located in:
[--Please select--]

28. What are the most relevant topics related to your highest academic degree? [Please check all that apply]

o	Biology	o	Geography (human)
o	Ecology	o	Economy
o	Physics	o	Anthropology
o	Agricultural sciences	o	Political sciences
o	Forestry sciences	o	Sociology
o	health	o	Psychology
o	Geography (physical	o	Education sciences
o	Other		

29. Do you consider yourself to be part of the ecosystem management research community?*

o Yes o No o Not sure

Thanks!

Thank you very much for participating in this survey.

Would you be interested in sharing your opinions on interdisciplinary work in a telephone interview within a couple of months? *

- o Yes, I am willing to take part in an interview.
- o No, thank you. My participation in this project ends with this survey.

(The next section appears if the answer to the previous question is "yes, I am willing to take part in an interview")

Protection of Privacy – Any personal information requested bellow is collected under the authority of Section 33 (c) of the Alberta Freedom of Information and Protection Privacy Act and will be protected under Part 2 of that Act. It will be used for the purpose of contacting participants for an interview appointment.

For an interview appointment, my contact information is: *

E-mail address	
Name	

Would you like to receive an electronic copy of a final report of this project?*

- o Yes, I would.
- o No, I would not.

(The next section appears if the answer to the previous question is "yes, I would")

Protection of Privacy – Any personal information requested bellow is collected under the authority of Section 33 (c) of the Alberta Freedom of Information and Protection Privacy

Act and will be protected under Part 2 of that Act. It will be used for the purpose of sending participants a report of this project.

The report can be sent to: *

E-mail address	
Name	

If you have any questions or comments about the study, please contact us at:

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Thanks Again!

Appendix 4. Interview guide

Introduction and consent

(*After scheduling an appointment by e-mail, where I introduce the study and ask for their participation)*

Hello, good morning. Dr. _____?

Hi, this is Anna Pujadas, I am calling for the interview on interdisciplinary work.

First of all, I would like to thank you for agreeing to participate in this interview. I really appreciate it.

Before we begin, I would like to take care of some practicalities. This project has been approved by the Research Ethics Board of the University of Alberta. Under accepted ethics obligations I guarantee your confidentiality and the confidentiality of the information you provide.

The interview will be tape recorded (with your permission), transcribed verbatim, and returned to you to check accuracy and add or remove anything you wish.

During the transcription process, you will be assigned a pseudonym, and any identifying information will be removed from the text.

The information you provide will be combined with the information provided by other participants, and will be used for my PhD thesis. Results of the study may be presented at scholarly conferences, published in professional journals, or presented in class lectures.

The recording of our conversation will be destroyed at the end of the project (in 4 years). However, the transcribed text file will be retained for 10 years in a secure, locked, and protected site at the University of Alberta.

At any moment, I am willing to listen to any issues, observations and concerns you have related to the project. You can contact me at my e-mail or my research supervisor, Dr. Garvin. The e-mail I sent you to schedule this interview has our contact information.

Your participation is voluntary and you can choose to stop this interview at any time, or to withdraw at any moment during the research project. Do you agree to participate?

If "no": Then, am I right to say you prefer not to participate?

If "yes, you are", then*:* I am sorry to hear that. Thanks anyway. (*End of the interview*)

If "no, you are not", then: Thank you.

If "yes": Thank you.

With your permission then, I will be electronically taping this interview. Do you agree?

If "no": I am sorry to hear that. Thanks anyway. (*End of the interview*)

If "yes": Great, thank you very much.

Do you have any questions before we get started?

Research context

Can you tell me a little about yourself and your research activity?

Topics to talk about:	Research activity, main research topics, disciplines involved Interaction with other academics/fields, other sectors

The concept of interdisciplinarity

Some people see the concept of interdisciplinary work as related to the interaction between disciplines, and some people see it as related to the interaction between academics and other social sectors. Do you think both kinds of interaction are part of interdisciplinary research?

Topics to talk about:	Definition of interdisciplinary work in EM Differentiation between the two interactions Relation between the two interactions

Terminology for interdisciplinarity

Some people see the terms 'interdisciplinary', 'crossdisciplinary', 'transdisciplinary', and 'multidisciplinary' as synonyms, and some people don't. Why do you think some use the terms interchangeably and some not?

Topics to talk about:	Differentiation between terms Discussions about terminology

The interdisciplinary process

How would you explain the process of doing interdisciplinary work?

Topics to talk about:	Curiosity-driven vs. intentionality-driven Intuition-driven vs. reasoning-driven
What do you think are the most important activities to do (steps to follow) when doing interdisciplinary work?	
Topics to talk about:	Description of activities Importance of activities Agreement or not among researchers about activities
What do you think defines 'good' and 'bad' interdisciplinary work experience?	
Topics to talk about:	Description of criteria Importance of criteria Agreement or not among researchers about criteria described
Do you think there are like 'rules' or 'accepted ways of doing' interdisciplinary work?	
Topics to talk about:	Description of the rules Importance of rules, and particularly the ones described Agreement or not among researchers about rules described
There is a group of people in fields such as sociology or philosophy of science that study interdisciplinary work. In a deductive way they propose a set of steps and activities for doing interdisciplinary work. Do you think these steps might be useful in your field?	
Topics to talk about:	Usefulness and contributions of theory
Discussions about the process In your opinion, do people in your field talk about how interdisciplinary work is carried out?	
Topics to talk about:	Particular focus of discussions Importance of discussions
Efficiency of interdisciplinary work Is there anything you think might help your field make interdisciplinary work more effective?	
Topics to talk about:	Contributions to interdisciplinary efforts

Close

This is all I wanted to talk about. Is there anything else you want to add?

Gratitude and goodbye

Thanks a lot for this talk. It will be very helpful for the project.

The interview will be transcribed and I will send it back to you to give you the opportunity to add or delete anything you said, or to provide feedback if you wish.

Do you want me to keep you informed about the overall results of the study? I can send you a report by e-mail once the study is concluded.

If "yes", Ok. Then, I will send you the interview transcript in case you want to review it, and latter on a report of the study.

Thank you again for participating. If you have any questions regarding this study, or questions regarding the issues we discussed, please feel free to contact me (or my research supervisor) at the contact information provided by e-mail.
(*End*)

If "no". Ok. Then, I will just send you the interview transcript in case you want to review it.

Thank you again for participating. If you have any questions regarding this study, or questions regarding the issues we discussed, please feel free to contact me (or my research supervisor) at the contact information provided by e-mail.
(*End*)

Appendix 5. Researcher psoitionality

Being reflexive about my own positionality as a researcher is to think about how I influenced the particular methods I used, how I produced knowledge, and the particular way I interpreted the data and findings. Acknowledging my positionality or subjectivity situates me as a researcher and the knowledge I produce in the context from which I speak. In an effort to strengthen my ethical commitment to conduct rigorous research, this appendix aims at briefly discussing the six traits about myself that I consider most importantly shaped the research.

First, I was familiar with ecosystem management (EM) research prior to starting the project. Familiarity with the field of EM allowed me to disregard general and theoretical questions associated with the field of EM. By using my background in EM I could directly tackle practical challenges of EM researchers in doing interdisciplinary work without previously inquiring about contextual information about EM and the EM community. On the other side, being familiar with EM might have resulted in taking for granted and overlooking certain terminologies and perspectives of participants, which was partially solved by reporting results to participants and asking them for feedback if they thought it was required.

Second, I had no background in theories of interdisciplinary research at the start of the project. The lack of a previous general knowledge about theories led me to spend a lot of effort to understand such theories and bridge the fields of interdisciplinarity and EM. This effort was later on translated into formulating research questions that included very specific details about meanings and uses of the concept of interdisciplinarity. These details are adequate for the field of interdisciplinarity, but they are not necessarily adequate for EM researchers' particular language and understandings about the concept. Triangulation of information when talking to participants was the main measure used to overcome this weakness.

Third, I am female. Although gender was not a specific topic dealt with in the project, it spontaneously arose when talking to some participants. It especially came up when talking with female researchers who referred to particular challenges related to working in academia and doing teamwork in a mostly male-dominated environment. Being a woman myself allowed me to be empathetic with such difficulties and give them a place in my findings. In addition to being female, being a mother helped me to be empathetic with the particular challenge of finding a balance between research and family.

Fourth, I had a maximum of four years to do my program. This situation made me base the research questions on topics carefully selected to target specific objectives. The program was framed by and constrained on a research proposal that delineated specific research steps and fitted them in a conservative timeline. Restricting the study to the research proposal allowed me to manage to do my program in four years. However, it probably resulted in missing interesting

research paths not foreseen when designing the study, which might be covered outside the program, in future research.

Fifth, English is not my first language. The lack of proficiency in English drove me to use clear and basic language when collecting the data, analyzing them, and reporting results. I inevitably missed some subtleties of the language. For that reason I relied on support resources from the university and the constant help of my supervisor and colleagues.

Finally, I am at a Canadian university. Regarding this point I think there are two important factors that influenced the research. One, the questions I asked and the way I addressed them had to be subjected to cultural standards with which I was not familiar. This difficulty was overcome by sharing detailed information about my conversations with participants with my supervisor, and by providing this information when submitting the project for the University's ethics approval. Second, I faced difficulties getting research funding as an international student. However, through the university I had open access to an important number of academic information sources, and I had the opportunity to use specific software to assist the data analysis.