AN ABSTRACT OF THE THESIS OF

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Abstract Approved____
Bruce Shindler

Integrated research that attempts to bring together social, biological, and physical variables is a recent phenomenon in natural resources. Scientists, land managers, politicians, and society as a whole have recognized that in order to produce optimal decisions for both humans and the environment, research on the interactions between the two is increasingly necessary. Although many projects have attempted integration, little is known about how these projects have been set up, what barriers they have encountered and what can be learned from past efforts. This research reports on five Pacific Northwest self-defined "integrated" projects, and uses qualitative methodology to understand what can be learned from efforts to bring together scientists and natural resource agency personnel to study relationships between natural and human systems.

In order to determine how integrated research was viewed by those who have participated in it, a comprehensive literature review and interviews with integrated project participants were conducted. These interviews explored how project participants defined integration, whether they felt their projects achieved integration, and important barriers and substantive factors affecting the success of integration.

Findings revealed that barriers to conducting integrated projects include the effects of disciplinary differences and roles in projects, institutional barriers in academia and agencies, and funding issues. Important factors that affect integrated research include time allotment, context and scale issues, capability of leadership, team composition, and the effects of differing definitions of integration. Recommendations for future projects include planning with time for disciplines to understand each other, physical proximity for team members and leadership, and defining questions together at the beginning of the project. These findings suggest that integrated efforts will require up-front time spent on planning, developing integrated questions, and building relationships, and that integration itself is an ongoing, iterative process.

INTEGRATED RESEARCH IN NATURAL RESOURCES: AN EXPLORATORY ANALYSIS OF FIVE CASE STUDIES

by
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APPROVED:

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Elaine Susan O'Toole, Author

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DEDICATION

Dedicated to my family, without whose constant love and support this thesis and my academic career would not have been possible, and to Dr. Brent Steel, who made me believe in myself and strive to make the world a better place.

INTEGRATED RESEARCH IN NATURAL RESOURCES: AN EXPLORATORY ANALYSIS OF FIVE CASE STUDIES

CHAPTER 1

INTRODUCTION

In recent years a series of conversations has begun to take place between scientists in many diverse disciplines regarding the need for and difficulties involved in interdisciplinary, integrative research on the relationships between human and natural systems (termed "socioecological" in recent literature). Although researchers have routinely conducted assessments on a variety of subjects related to management goals and resource conditions, it is only recently that attempts have been made to conduct integrated social, economic, and ecological evaluations across large geographic regions (Lessard et al, 1999). In this thesis, the processes associated with these types of assessments will be examined to inform future integrated socioecological research attempts.

With the rising environmental consciousness of the 1970s onward, many federal and state laws and policies have mandated consideration of biophysical factors along with inclusion of human consequences in natural resource management. These include the National Environmental Policy Act (NEPA), the National Forest Management Act (NFMA), and the Endangered Species Act (ESA). As the courts and policymakers have interpreted these laws to mean that consideration of social, economic, and biophysical elements must be included in management plans, there has been increasing attention paid to how these factors interact with each other. There has also been an increasing recognition on the part of policymakers and scientists that consideration of the social and political underpinnings of natural resource management decisions is necessary to fully understand socioecological interrelationships (FEMAT, 1993, Clark et al, 1999).

Thus, professionals in scientific, policy, and land management communities increasingly recognize “integrated research” is necessary to reconcile the separate biological, physical, and social systems so that better understanding, management solutions, and predictive capacity are achieved. With the growth of the "ecosystem management" paradigm in scientific and policy communities, study of the interrelationships between humans and the natural world is emphasized, and methods for understanding their interactions are increasingly sought (Thomas, 1999). Furthermore, as complexity is being recognized as the norm in ecosystems, the degree to which separate biological, physical or socioeconomic models can explain this complexity is coming into question (Kohm and Franklin, 1997).

Although researchers and policymakers may agree on the need for integrated research to understand socioecological system complexities (and early attempts have been made), many aspects of this type of research are poorly understood (Clark et al, 1999). For example, although a wide variety of natural resource research projects and assessments have been deemed interdisciplinary or integrative in nature by participants, the difference in these projects' goals, processes, and outcomes suggests that no simple definition exists or may even be possible. Furthermore, because of the vast degree of difference in these types of projects, there is little agreement on how to uniformly undertake interdisciplinary, integrated research in natural resources.

Recent examples illuminate methodologies that attempt to take an interdisciplinary, integrated approach. For example, systems theory is increasingly being recognized as an alternative to the traditional scientific method. Instead of reductionism and experimental analysis within discrete scientific disciplines, systems theory combines issue and scale appropriate approaches which include historical, comparative, and experimental components (Holling, 1998). Systems theory suggests that the degree to which these models can be integrated in an additive manner is small, therefore a more holistic approach is warranted. Thus, systems theory is an early example of how study of biological, physical, and social systems can be integrated.

Examples of smaller attempts at integrated research include a recent study combining spatial elements of fire across a landscape with management alternatives (Johnson et al, 1998) and the characterization of historical range of variability for disturbances and vegetation in the H. J. Andrews forest in Western Oregon (Cissel et al, 1998). These types of projects usually explore fewer variables, but may look at interactions at a finer scale than regional assessments and reveal a great deal of useful information about the processes in a specific forest ecosystem.

Another example of integrated research are projects commonly known as "integrated resource assessments". Whereas in the past natural resource agencies have focused on narrow questions and issues related to resource usage (such as the population status of an endangered species or supply and demand for a resource), more recent assessments have begun to address the shortcomings of these procedures. These new types of assessments—frequently referred to as landscape level studies—are intended to focus on broader geographic areas or multiple issues, and have evolved to include many diverse participants. For example, a recent study in Western Oregon focused on the interactions between forests, riparian areas, and wildlife in order to better characterize future management options for stakeholders and agencies alike (COPE, 1999).

Bioregional assessments are integrated resource assessments at the most extensive scale. These include studies such as the one completed by the Forest Ecosystem Management Assessment Team (FEMAT, 1993), which attempted to bring together socioeconomic and biophysical variables within the context of the spotted owl controversy in Pacific Northwest forests, and the Interior Columbia Basin Ecosystem Management Project (ICBEMP, 1999) which worked to characterize the resources of a large region and then delineate various management alternatives and their outcomes. In these types of assessments, university and agency researchers attempt to study both the components and processes of large geographic regions, usually with the goal of providing information that leads to improved, more holistic management of these areas.

While there is an emerging body of literature on the *results* of interdisciplinary, integrated research projects, little information exists on how participants in this process regard it and what can be learned from their experiences. It is not clear if there are central themes or lessons that can be compiled and consolidated to guide future attempts at interdisciplinary, integrated research, or if common problems are encountered by individuals participating in these projects. Furthermore, because attempts at this type of research are relatively new and so diverse, few researchers have formally reflected on the processes employed or what they might have learned about their interactions with other scientists and various methodological approaches.

This thesis is the first step in what is intended to be a long-term, longitudinal study of the interactions between social and natural elements of Pacific Northwest forest ecosystems. The purpose of this exploratory study is to examine several recent attempts at integrative, interdisciplinary research conducted in the Pacific Northwest and to capture the learning that has occurred among participating scientists. Using data from interviews with scientists and drawing from the research literature on integration, this study identifies critical elements affecting the design and implementation of integrated research projects; describes a set of barriers commonly found among research teams; and examines important factors that affect the process and outcomes of such efforts. The thesis concludes with a series of recommendations based on the interviews with participating scientists.

The methods for this thesis project involved first a comprehensive literature review to explore the important issues surrounding integrated research, to identify key factors for examination, and to help establish a set of questions and interview protocol. The researcher then set up a series of interview questions with participants from five different projects that were self-described as "integrated research", as well as individuals knowledgeable about this type of research. The research objectives of the study are twofold: first, to develop a better understanding of how integrated natural resource research is conducted, and second, to capture the knowledge that has been gained in recent efforts.

CHAPTER 2

CONTEXT

The general context for this thesis project is the Pacific Northwest and the changing face of natural resource management and research in that region. Wilkinsen (1992) wrote of the "Lords of Yesterday", laws, policies, and ways of thinking from previous centuries which have been the foundation for natural resource management in the West. These include use of resources solely for human needs, the unlimited bounty of resources in the region, and unfettered development of timber, minerals, animal and fish species, and rangelands.

In the last half century, however, it has become clear that increased human population and demand, combined with a shrinking natural resource base, have made many of these ideas not only obsolete but also dangerous. Passage of laws such as the National Environmental Policy Act (NEPA), the National Forest Management Act (NFMA) and the Endangered Species Act (ESA) heralded the beginning of environmental consciousness and accounting for other public values such as viability of species and conservation of habitat. Calls for "sustainability" and "ecosystem management" have permeated the region as land mangers and policymakers have searched for ideas that can encompass these new values.

In the Pacific Northwest, these changing public values and agency implementation attempts were played out in the legal arena in the famous spotted owl battle. After passage of the ESA in 1973 the spotted owl was designated an "indicator species" under NFMA, and state and federal biologists recommended that three hundred acres of land be set aside for each pair of birds in 1986. The Forest Service formulated a strategy to protect habitat for the owl, but conservationists (including the Seattle Audubon Society) sued the Service for failure to adopt a credible plan because of the amount of logging allowed in the protected areas. After an injunction against the timber sales was issued in 1989, Congress stepped in and passed a rider to allow logging for two years under the Forest Service Plan. In response a variety of citizen advisory committees as well as several executive branch panels (such as the Interagency Scientific Committee and the Gang of Four) examined the issues and made recommendations in the following four years.

In 1993, the Northwest Forest Conference was convened by President Clinton to attempt to find some way out of the legal gridlock in the region on these contentious issues. The question that the president posed to the attendees was how to achieve a balanced and comprehensive forest policy that both recognized the importance of timber and jobs to the region and also preserved the old-growth forests of the Pacific Northwest, which are part of the national heritage of the country.

To answer this question the President created three task forces, which would work for sixty days to devise a plan to meet the legal requirements for species protection and forests, as well as to account for the economic and social factors. This Forest Ecosystem Management Assessment Team (FEMAT) produced several options for consideration by the Administration. Eventually an alternative (Option 9) was chosen, and the Forest Plan that resulted from it passed judicial muster (with some qualifications about future implementation) in 1994. This alternative included the establishment of 7.05 million acres of reserves and designation of a further 2.23 million acres as riparian areas. Although approximately 7.34 million acres is available for timber harvest under the plan, much of this is unsuitable for various reasons.

FEMAT was one of the first attempts in the Pacific Northwest to bring together social, biophysical, and economic considerations in some sort of integrated manner, but it was not necessarily about doing traditional research or science. Instead, it brought together existing knowledge and data from which alternative policy choices to meet a specific objective were formulated. Other projects have built upon this legacy, as researchers who were involved in FEMAT have taken questions that the project did not answer to formulate subsequent integrated research efforts. These include the later stages of the Coastal Oregon Productivity Enhancement Program (COPE) which attempted to do primary research to answer some of the questions generated by FEMAT for which primary data did not exist. The Coastal Landscape and Modeling Study is also building on the need identified in FEMAT for landscape level data on the interactions between ownership patterns and natural resource use. Individuals involved in both of these projects (as well as FEMAT) were interviewees for this thesis project.

Another outcome of the FEMAT process was the creation of ten Adaptive Management Areas (AMAs) upon which to test new integrated forest management approaches. One of these areas is the Central Cascades AMA near the McKenzie River in Oregon. Many of the scientists and managers interviewed for this project are associated with this AMA (and the H.J. Andrews Experimental Forest contained within it), and the projects they have participated in are based there. Even before the FEMAT process, however, the researchers affiliated with the H.J. Andrews Forest set up long-term integrated research projects, some of which are intended to continue into the next 100 years. Most of these projects deal in primarily biological and physical data, but social interactions with surrounding communities are being considered as the subject matter for future research.

With the success of the Forest Plan process, President Clinton directed the Forest Service and the Bureau of Land Management to undertake the formulation of a comprehensive plan for management of their lands in the Columbia River Basin. The Interior Columbia Basin Ecosystem Management (ICBEMP) project undertook research to answer baseline questions about the state of the region's natural resources, and social and economic conditions. This research took several years, and revision of the Environmental Impact Statements that resulted from ICBEMP is still ongoing.

As the above projects (as well as myriad other research, planning, and management programs) have proceeded under both academic and agency auspices, the paradigm of "ecosystem management" has also evolved. This concept in natural resources has roughly come to mean inclusion of social and biophysical variables over large spatial and time scales. Along with the evolution of public values toward this more holistic approach, several other important issues affecting integrated research attempts have surfaced in the arena of natural resource management within the Pacific Northwest in recent years. Some of these include management for fire, landslides, other disturbance events, and the emergence of extinction of anadromous fish such as salmon and steelhead as salient issues to much of the population of the region.

These problems are increasingly seen as interconnected with many different facets of forest management and human society, and there have been intensifying calls for interdisciplinary research to understand these relationships. The holism of ecosystem management has intersected with problems that are seen as multifaceted and complicated. Therefore, integrated, multidisciplinary research is on the cutting edge of the attempts to find solutions and to generate predictive capacity within natural resource management in the Pacific Northwest. This thesis will explore the viewpoints of the participants in five such research projects on how these integrated research efforts have come about and functioned, as well as what barriers were encountered in the process and what factors contributed to the success or failure of these efforts.

CHAPTER 3

METHODS

3.1 RESEARCH QUESTIONS

In order to explore the issues important to integrated research efforts the researcher set up a series of research questions based on a literature review. These research questions were then used to develop an interview questionnaire that was administered to past participants in the integrated research case studies discussed below. Individuals who were recommended by the original interviewees as being knowledgeable about this type of research were also interviewed. (See Appendix 1 for questionnaire). The research questions are as follows:

1) How is integrated research viewed by those who have participated in it, and how are the processes within it defined? Does this differ depending on type of project, and if so, how?
2) How do the backgrounds and worldviews of those who engage in integrated research affect their views and participation in it?
3) What types of barriers exist to integrated research, and how are these barriers viewed by participants?
4) What are the substantive factors that affect the success or failure of integrated research projects?

3.2 CASE STUDIES

Five separate research projects of varying size and type conducted in the Pacific Northwest were chosen as case studies for this thesis. The researcher was interested in both whether there were common threads between the different types of integrated research as well as in the specifics of each case study. The five projects chosen for the research project were the Forest Ecosystem Management Assessment Team (FEMAT), the Interior Columbia Basin Ecosystem Management Project (ICBEMP), the Coastal Oregon Productivity Enhancement Program (COPE), the Coastal Landscape and Modeling Study (CLAMS), and the Cooperative Forest Ecosystem Research (CFER) Program. General descriptions of these projects obtained from the interviews and the literature produced by the actual projects are below, and the major research objectives and foci of each will be delineated. Also included will be aspects of the projects that are relevant to the thesis research questions, such as the way projects were managed and the types of scientists who were affiliated in the projects.

3.2.1 Forest Ecosystem Management Assessment Team (FEMAT)

The Forest Ecosystem Management Team was formed in response to President Clinton's Forest Conference held in 1993. This conference followed numerous legal battles and committee reports on spotted owl habitat and old growth forest issues in the Pacific Northwest over the previous fifteen to twenty years. FEMAT was made up of both agency and academic scientists, and was charged with producing within 60 days a plan to integrate economic and social considerations of the region with the legal requirements for species and forest protection. The majority of scientists involved in FEMAT were biological and physical scientists, but economists and social scientists were also included. Most of these individuals were men because at that time most senior scientists in the fields represented were men, but several women were also included as researchers in each scientific category. FEMAT was run as a "top down" project, with Jack Ward Thomas, the Chief Research Wildlife Biologist of the Forest Service's Pacific Northwest Station leading the effort and various scientists heading up each team.

The mandate of FEMAT changed over the course of the teams' work, from production of a single alternative to developing several options for consideration by the President and other policymakers. The process followed involved three phases: development of options for a matrix of reserves and managed forests, along with selection of an option and formulation of the Environmental Impact Statement (EIS) required by NEPA; formulation of the EIS for the preferred alternative; and implementation, monitoring, and adaptive management. Thus, the process of FEMAT is still ongoing, although this thesis will only consider the first two phases of the project.

The process of FEMAT involved bringing together ideas that met the President's mandate, generally from previous research, reports, or management plans. Because of the time constraint, no new research was done. Eight options for management of the forests involved were eventually chosen to be fully evaluated.

After analysis of these options, however, it became clear that although they met the biological requirements of the President's mandate they did not meet the timber production levels desired, nor the core ecosystem principles judged to be important. Another option, Option 9, was developed to fully incorporate ecosystem principles with the higher timber cutting levels desired by the administration.

The initial phase of FEMAT eventually developed a list of alternatives, each of which was evaluated for its level of protection of species and ecosystems, and economic and social effects. The biological analysis was based on whether the alternatives provided adequate habitat to support viable populations of species associated with late successional forest, as well as anadromous fish, and whether distribution of these forests was even across the federal forests. The social/economic analysis examined timber harvest levels, including economic analysis of markets, estimating timber industry employment, and assessment of economy wide effects. This side of the analysis also included a prototype assessment of social considerations including: community level effects from declining timber harvest levels; social values connected to resources from federal lands; the public definition of issues related to forest management; and the history of the current problems.

FEMAT was one of the first attempts to bring social, economic, and biophysical considerations into some sort of integrative framework in natural resource management. It was not original research, instead it relied upon a synthesis of existing knowledge to reach new conclusions and the creation of new knowledge (Norris, 1999). While many new concepts of management and integration were articulated and formulated within the FEMAT process, the success of the Northwest Forest Plan is still under scrutiny and its science ongoing.

3.2.2 Interior Columbia Basin Ecosystem Management Project (ICBEMP)

The ICBEMP was an offshoot of the Northwest Forest Plan, as President Clinton directed the Forest Service and the Bureau of Land Management to develop a scientifically sound, ecosystem-based strategy for the national forests in Eastern Oregon and Washington. The three priorities of the Project are protection of ecosystems; restoration of deteriorated ecosystems; and providing multiple benefits for people within the capabilities of the ecosystem. The ICBEMP covers 144 million acres, portions of 7 states, 100 counties and 22 tribal governments, and includes some of the most diverse ecosystems in the nation.

The project charter specified preparation of two Environmental Impact Statements, a scientific framework for ecosystem management, a scientific assessment of the basin, and a scientific evaluation of the EISs. The scientific assessment was released in December 1996, and two EISs (for the Upper Columbia River Basin and the Eastside) were released for public comment in June 1997. A supplemental Draft EIS that incorporated public comment was released in April 2000.

The Scientific Assessment involved over 300 scientists from state and federal agencies, universities and the private sector. There were several offices for the project, with the main headquarters set up in La Grande, Oregon. The project was managed from the top down, but with more diversity than FEMAT. There was a leader of the project, but the scientists were divided up in a wide variety of teams whose members often never knew each other. The leaders of these teams would meet periodically to update each other on the team's progress, and often these lead scientists were responsible for allocating work in their teams and writing the publications that came out of the project.

Although there was still a higher percentage of men than women, the ratio was more equal in the ICBEMP than in FEMAT. In the beginning most of the members of the Science Integration Team (SIT) responsible for the assessment were volunteers who reported to the various teams organized around the central themes of the analysis. These teams included terrestrial analysis, landscape ecology, aquatic resources, economics, and social factors. The SIT identified the information needed for the assessments, planned the process needed to gather the information, and monitored and evaluated the work of the teams on the assessments. The SIT was also responsible for integrating the information received from the teams using a framework of six ecosystem goals.

The materials generated by the project have received mixed reviews. A great many publications and data sets resulted from the work done, giving policymakers much information. But most of that information is at a fairly high level of data resolution, both because of the project's mandate to look at the system as a whole and the sheer geographic scale of the area examined. Thus, the data is better suited for broad decisions about policy for the area than for revisions at the species or community level. The project was also marred by political issues that threatened its survival early on, as congressional opponents to the Clinton Administration attempted to cut funding for the ICBEMP. The project survived, however, and both the BLM and Forest Service as well as some state agencies are currently using information gathered by the projects to plan future management scenarios.

3.2.3 Coastal Oregon Productivity Enhancement Program (COPE)

The COPE program began in 1987 and officially ran through 1998. It was jointly administered by the U.S. Forest Service's Pacific Northwest Research (PNW) Station and the College of Forestry at Oregon State University. Other groups who cooperated in the effort included the USGS Biological Resources Divisions; the Bureau of Land Management (BLM); other federal and state agencies; county and city governments; the forest industry; and the Confederated Tribes of the Grande Ronde.

The goal of the project was to develop knowledge that would increase economic and social benefits derived from the forests of the Oregon Coast Range. The project had a two-pronged focus: to develop new information on reforestation and riparian zone management, and to share that information about improved management techniques with users. Therefore, the project structure had two parts: Fundamental COPE, in which scientists from the PNW Station and the College of

Forestry did basic research to develop information, and Adaptive COPE, which was an interdisciplinary team that conducted some research, tested the applicability of existing studies to the Coast Range, and did outreach to professional audiences on the findings of the project. The Adaptive COPE team was the main focus of the interview portion of this project because of its interdisciplinary nature, although some members of the Fundamental COPE program were also interviewed. The Adaptive COPE team was stationed in Newport, Oregon for the main part of its work, while the Fundamental COPE team worked out of Oregon State University and covered much of the Coast Range in its research. The Adaptive COPE program was primarily male, (although one woman did participate for several years in the project) and was run from the top down.

The COPE program began by holding a series of workshops in local areas of the Oregon Coast Range. Citizens, resource managers and community leaders were asked what types of information they needed to make better decisions concerning the forest resources of the region. Out of these workshops an Advisory Council was established to represent the views of the various constituencies involved. This Council provided direction for the research efforts as well as guidance on information needs and priorities. Under advice from the Advisory Council the COPE program decided to focus its research specifically on riparian systems and the interactions between management of upland forests, reforestation opportunities and wildlife habitat (COPE, 1999). However, the COPE process did not necessarily involve integrated questions from the beginning; often the scientists would perform research in their own area of specialization and then try to integrate the results with those of other project scientists afterwards.

As with the other projects profiled in this section, the COPE project produced reams of data, information, and publications. Scientists associated with the project have learned a great deal about everything from wildlife numbers and habitat requirements to the role of large woody debris in the life cycle of anadromous fish populations. Data has also been acquired about the interactions between silviculture, wildlife, and riparian issues, much of it from Adaptive COPE projects that attempted an integrated, interdisciplinary approach.

3.2.4 Cooperative Forest Ecosystem Research Program (CFER)

The CFER program is an ongoing interdisciplinary project initiated in June 1995 to promote and facilitate ecosystem management on Bureau of Land Management lands in the Pacific Northwest. Several agencies are cooperating with the Oregon State University Colleges of Forestry and Agriculture in the program: the Bureau of Land Management, The Forest and Rangeland Ecosystem Science Center (FRESC) of the US Geological Survey, and the Oregon Department of Forestry. Like COPE, CFER is committed to both research and dissemination of information to a variety of audiences. However, unlike COPE, CFER began its work with a specific commitment to doing integrated, interdisciplinary research. The staff of CFER has a higher number of men as opposed to women, but instead of being run from the top down it is being managed by a group of lead biological and physical scientists who work together to set up projects. CFER has one administrator, but this individual mainly does the paperwork involved in directing the project. There are only about twenty-five individuals (scientists, graduate students, and researchers) currently listed on the CFER project, making it one of the smaller projects analyzed for this study. One unique feature of CFER is its full time information resources person who facilitates the interface between the public and the project and tries to keep information flowing between the stake holders in the study area and the staff of the project.

Integrated research as defined by CFER includes gathering knowledge across multiple disciplines, spatial scales, and geographic regions. Three major integrated projects were launched in 1999: examination of stand structure and biotic responses to changes in structure of young forests of Western Oregon; research on large woody debris production, recruitment, retention, and function in terrestrial and aquatic riparian zones; and influence of landscape pattern and composition on species in forested ecosystems of Western Oregon (CFER, 1999).

CFER quite deliberately began its research with planning that defined a "broad, interrelated, and integrated" set of questions related to the above three focus areas. These areas in turn were refined to a number of smaller studies designed to address essential elements of the questions and combine multiple objectives. Integration across projects is also a part of the CFER program, as is integration with findings from other research groups (CFER, 1999). Although CFER does not explicitly incorporate social variables and research, it was chosen for this thesis project because it is so specifically geared toward interdisciplinary, integrated research. The project is primarily located at Oregon State University, where the lead scientists all work.

3.2.5 Coastal Landscape and Modeling Study (CLAMS)

The CLAMS project is a recent offshoot of the COPE project, launched in part to answer questions that COPE was unable to explain. CLAMS, an ongoing study, involves multiple disciplines in an effort to develop tools such as GIS databases and maps to understand the patterns and dynamics of regional ecosystems such as the Oregon Coast Range. The project further hopes to study and analyze the aggregate ecological, economic, and social consequences of forest policies of different landowners in the Coast Range (CLAMS, 1998). The information developed by the project is designed to be used by policymakers to examine both existing and proposed forest management scenarios.

The co-operators for the CLAMS project are the Oregon State University Department of Forestry, the US Forest Service's Pacific Northwest Research Station, and the Oregon Department of Forestry. The project employs existing databases, GIS, remote sensing, and statistical analysis models of the interactions between both social and biophysical variables. Some of the different elements to be explored and mapped by the project include habitat conditions and relationships, general forest cover, vegetation cover, landownership patterns, and the linkages between forest structure and practices and ecological, economic, and social outputs.

According to CLAMS the research is designed to develop new habitat relationship models, quantitatively analyze current plans, and to answer major questions about forest management at large scales (CLAMS, 1999).

The CLAMS project is also run less top down than either FEMAT or COPE, with two scientists leading the effort to get funding for the project and other scientists working on various aspects of the research. The two lead scientists sought input from the members of the team on how to integrate the various components of the study, and from the beginning integrated questions to be answered were defined. CLAMS is mainly comprised of male scientists, with several female researchers working on various aspects of the project. The project is also smaller, and is primarily located at Oregon State University.

3.3 RESEARCH PROTOCOL

Using qualitative interview methods, this research project examined the experiences of 43 different individuals who have participated in these various projects. The individuals were chosen based on their level of knowledge and experience on these projects, as well as because they fit certain predetermined categories deemed by the researcher to be important. For example, the researcher attempted to interview female researchers even though most of the research projects were comprised mainly of men. Further, an attempt was made to get a mix of different types of researchers. These included newer researchers as well as senior researchers, natural resource agency personnel as well as academicians, and social and biophysical scientists.

Another technique used in the research was "snowball sampling", in which members of the case study groups were identified, interviewed and then asked to recommend other knowledgeable parties to that might be willing to be interviewed (Shutt, 1996). These participants were in turn asked to identify other individuals with expertise on the subject matter. In this way, the researcher tried to get a good cross section of individuals with different types of experiences in integrated, interdisciplinary projects.

3.4 QUALITATIVE RESEARCH

3.4.1 Research rationale

According to Shutt (1996), social science qualitative research includes four common categories: descriptive, exploratory, explanatory, and evaluative research. Descriptive research defines for researchers the phenomenon of interest. Exploratory research examines settings, meanings, and issues of concern. Explanatory research focuses on the causes and effects in relationships, and evaluative research gives attention to particular policies and programs that may alleviate problems. One of the major reasons for using qualitative research in social science is to explore a topic or to help us begin understanding its dimensions (Babbie, 1998).

The framework that has been utilized most frequently in this project is exploratory research, in which interviewees were asked questions to focus their responses on the settings of their research projects, the meanings of integrated research within their experience, and the issues which affected the research process and the ability of projects to achieve integration. Characteristics of qualitative research which make it suited for these types of questions include its fundamentally interpretive nature, its use of settings which take place in the natural world, and its attention to emergent ideas and phenomenon (Marshall and Rossman, 1999).

3.4.2 Interview Technique

Several important steps mark the long interview process. The first of these is the literature review, in which the researcher attempts to define problems and assess the state of current knowledge. Another function of the literature review is to give the qualitative researcher the background necessary to know what to expect in the interviews. This is called "sharpening the capacity for surprise", the process whereby the researcher well versed in her subject matter will be more attuned to counter-expectational data. It is important that the researcher recognize that preconceptions can also get in the way of good qualitative research, however, and guard against the effects of preconceived ideas stemming from the literature review (McCracken, 1988).

The next step in the research process is construction of the interview questionnaire. One of the major objectives of this study was to learn which variables were most important to the success of integrated research, and the interview instrument was designed with that in mind. Through use of open-ended as well as more focused questions, the researcher was able to obtain the necessary exploratory and unstructured answers, as well as make sure that the same terrain was covered in all the interviews. The researcher also designed "prompts" to get interviewees to be more forthcoming in their answers, and to allow for answers that might not be specifically addressed in the interview questionnaire.

Interviewing as a qualitative research technique has strengths and weaknesses that must be recognized by the researcher. Some of these include the necessity for cooperation, the recognition that interviewees may not feel comfortable sharing all the information that they know, and the possible limitations of the researcher such as asking the wrong questions or not fully understanding the answers given. Quality of the data is also sometimes an issue, as perspectives of the interviewees are simply subjective interpretations of their experience of reality.

Marshall and Rossman (1999) discuss some of the characteristics of interviewing individuals who are preeminent in their fields, and some of the advantages and disadvantages of this type of research. Individuals who are preeminent in their field are defined by these authors as influential, prominent, and well-informed people with an expertise in the area relevant to the research. Advantages to interviewing these individuals include gaining valuable information and perspective on an organization, and getting relevant information from those most familiar with the issues of interest. Disadvantages can include the difficulty in getting together with these busy individuals, the necessity of adapting interview questions because of the preferences of the interviewees, and the possibility that the interviewees may take control of questions to fit into their ideas and interests (Marshall and Rossman, 1999).

3.5 DATA ANALYSIS

One of the general approaches that the researcher used in this project is based on the grounded theory most closely associated with Glaser and Strauss (1967). Grounded theory perceives the interview and analysis process to be intertwined; as the interview data is gathered it is analyzed and the answers are used to guide subsequent questions. Therefore, although the researcher had a set of questions to be asked based on the literature review, questions were also built upon information collected from earlier interviews, and statements of the current interviewee.

After each of the interviews, the researcher wrote up summaries of the important issues and data that emerged. Interviews were tape recorded and often referred back to, in order to make certain that the most salient points were caught. The researcher was careful to come to the data analysis with an open attitude despite the preset research questions. Possible biases and preconceptions of the researcher were also carefully thought through and acknowledged so that they could be accounted for in the data analysis process.

Although the researcher considered use of a computer program to analyze the data, it was decided that much of the emotion and important points of the interviews could be lost in this process. Instead, the researcher used a content analysis approach to organize the data around the interview categories and themes that emerged from the interviews. Important quotes were then winnowed out of the interviews, and patterns from each individual interview as well as those that were repetitious or interrelated with other interviews were also recorded. Connective threads between the experiences of the interviewees were noted as were the areas in which experience differed significantly.

CHAPTER 4

LITERATURE REVIEW

4.1 INTRODUCTION

In this section, the literature related to the various components of this study is reviewed. First, the general concepts and underpinnings of interdisciplinary and integrative research are explored to examine how the literature depicts these terms. Examples are given of how interdisciplinary, integrated research has been attempted by past researchers and assessments, in order to form the foundation of the research question on how this type of research may be defined. Of these two terms, “interdisciplinary research” has been used more in the realm of social science, while “integration” or “integrative research” is more prevalent in natural resource research and management settings. Next, a discussion of the more holistic approach proposed by systems theory will be presented as an example of some of the theory underpinning integrated research.

Once the history of integrated research and how it is defined by researchers has been briefly reviewed, the literature on the effect of the backgrounds and viewpoints of those who participate in integrated research will be discussed. Because the field of integrated research in natural resources is fairly new, this literature is somewhat limited. Finally, the factors that affect the success or failure of integrated research and barriers to its implementation will be reviewed. Factors such as context, scale, funding, and leadership will be examined, as will barriers related to differences in disciplines, roles of individuals within projects, and institutional factors.

4.2 INTERDISCIPLINARY RESEARCH: THE SOCIAL SCIENCE VIEW

Disciplinarity in the sciences, both social and biophysical, was the norm in the nineteenth and twentieth centuries, as the evolution of the natural sciences and the industrial and agricultural revolution combined with technological advancement. Industry demanded specialists, and university students became part of increasingly individuated fields, each with their own scholarly institutions and sophisticated instrumentation, disciplinary rules and boundaries. These disciplines became characterized not only by a set subject matter, but also by the principle of scientific reductionism, which studies topics by breaking them down into their component parts. Thus, study of broad scale phenomena across disciplines became more the exception than the rule, and disciplinarity became institutionalized.

Research and interaction between disciplines reemerged in recent years, however, as there was a recognition of both the benefits of a more holistic education for students and the need for larger understanding of broad problems often involving large scale systems (Klein, 1990; Kline, 1995; Janssen and Goldsworthy, 1996).

In the realm of social science, the terms for research which included different disciplines were “interdisciplinary”, “multidisciplinary”, and “transdisciplinary”. Although definitions vary among social scientists about the meanings of these terms, generally the following ideas from Klein (1990) predominate:

Multidisciplinarity essentially refers to an additive model in which practitioners of different disciplines interact to present differing viewpoints within a common setting. Examples might include individuals from different disciplines coming together to teach a class from different viewpoints, or researchers assembling a report on a topic from the points of view of various disciplines.

Interdisciplinary work, in contrast, emphasizes integration of disciplines and topics, and the achievement of an understanding of the interrelationships between them. Implied in this term is that the result is more than the sum of the disciplinary parts in some significant way. Systems theory covered later in this literature review is an example of interdisciplinarity. Another example is the field of environmental science, which has emerged as a synthetic discipline to address problems such as water pollution or Third World environmental problems by providing students with interdisciplinary training (DeGroot, 1992).

Transdisciplinarity carries these concepts even further, as it embraces such concepts as general systems science, and creates synthesis disciplines and frameworks that can make disciplinary approaches subordinate. Some examples of academic transdisciplinarity include peace studies, human population biology, and cultural futuristics (Klein, 1990). The social science term "interdisciplinary" and the natural resource research/management term "integrative" (covered in the next section) will be used interchangeably in this thesis, as there is a large degree of overlap in the concepts.

Several writers have noted that the instances of and forums for interdisciplinary research have increased in recent years. Kline (1995) discusses how the expansion of human knowledge and associated perils have left us with little in the way of overviews of the world or human knowledge as a whole, thus creating the climate in which more holistic approaches and systems theory emerged. Because of this expansion, neither the physical nor the social sciences alone have the ability to provide a complete worldview; thus an integrative approach is needed. Klein (1990) described academic institutions, such as the University of Chicago, that emphasize interdisciplinarity at many levels, from courses to dissertation committees, as well as agencies and institutes that emphasize interdisciplinary research. A recent National Science Foundation Request for Proposal "promotes a systems-level approach for expanding scientific understanding of large-scale environmental issues and assumes that an interdisciplinary approach will be required" (NSF, 1999). Other agencies from the Environmental Protection Agency to the U.S.D.A. Forest Service and Bureau of Land Management have also increased funding for interdisciplinary research in the last few years, although these agencies tend to use the term “integrated research” instead.

4.3 INTEGRATED RESEARCH IN NATURAL RESOURCES

The term "integration" and the research associated with it have also emerged in recent years, in both academic fields such as forestry or fisheries and wildlife, and in natural resource agency settings. Legally, the agency prescriptions of the National Environmental Policy Act to take social as well as biological impacts into account in the formulation of Environmental Impact Statements forced consideration of a wide variety of variables, as well as attempts to find methodologies to explore them. Political pressure from both local and national governments to assess the impacts of natural resource management actions has also led to more integrative assessments of policies and their effects on local communities. The Forest Service now routinely conducts community information sessions on policies that it promulgates in an attempt to get local feedback and suggestions, as well as local buy in and support.

Integrated research on the variables important to natural resource agencies has coincided with and informed an integrated model of management. The prevailing model of "ecosystem management" (EM) which agencies and academia alike have attempted to define and operationalize in recent years has followed this emphasis on integration of human and natural variables in research and management. Thus, integration in research often overlaps with integration in management, in that multiple viewpoints and types of data are seen as necessary to achieving the optimal understanding of, and response to a complex problem. (Pickett et al, 1999; Johnson et at, 1999).

Despite the emphasis and exploration of integrated research and management, however, little agreement seems to exist on how to define the concept. There almost seems to be more information on what integration *is not* instead of what it is. For example, Clark et al (1999) wrote:

> "There is a tendency to think of integration as simply fitting different disciplines and functional issues together, of adding perspectives to one another. Integration is far more than this, however; it involves development of a comprehensive process, founded on integrative questions, with multiple values, scales, tenures, uses, etc. It involves more than assembling massive collections of data joined only by the staples that hold the final report together; more than collections of overlays, whether generated by hand or by sophisticated GIS systems; more than bringing specialists from a variety of disciplines together; more than simple proclamations that "we have taken an integrative approach . . . (p. 315).

Later these same authors state that integration is and will be an integral part of future natural resource management and research, especially since there is an increasing demand for the goods and services provided by natural resources that are themselves becoming scarce. Integration is further defined as a process instead of a particular outcome, and involves respect for other viewpoints, meshing of different disciplines across temporal and spatial scales, and dependency upon knowledge from many different sources. (Clark et al. 1999).

Resource management within the agency arena from the times of Gifford Pinchot in the early twentieth century has subscribed to a somewhat more limited idea of integration. Pinchot advocated both cooperation between agencies and treatment of natural resource problems as single questions with several parts. (Steen, 1976). Mitchell (1990) argued that the traditions of both U.S. and Canadian agencies support integration, which he defined as involving four components: "multiple purpose, multiple means, and multiple participant strategies; blending of various resource sectors; using resource management as a mechanism for social and economic change; and striving for accommodation and compromise (p. 22)."

Lang (1990) described the current environment for natural resource agencies as one in which the rise of environmental groups and impact assessment requirements has led to an acceptance that often only through integrated assessments can decisions which are publicly acceptable and ecologically sound be made. Integration is seen as a process that seeks balance between a wide range of considerations, and which incorporates many objectives and interests. Further integration is also seen in models and research which combine social and biophysical dimensions through both academic research and extension work. (Bexdicek and DePhelps, 1994; Clark et al, 1999). For example, Janssen and Goldworthy (1996) discuss a four-part typology with various levels of integration in natural resource management (see Appendix 2).

Bexdicek and DePhelps (1994) described a systems level perspective which is used to solve problems associated with agriculture and natural resource management. Social and biophysical scientists come together with community interest groups in interdisciplinary teams to tackle issues such as why farmers resist change, the examination of whole farm systems (from economic factors to production practices), and understanding how cover crops can reduce leachate of fertilizer.

Several academic models have also attempted to incorporate human and natural variables in some integrative manner, and these merit some examination as early efforts at integration. The first of these discussed below is the *Human Ecosystem Model* of Machlis et al, (1997) and another is *Integrated Ecological Assessments* as described by Lessard et al (1999). *Integrated Regional Models* (IRMs) are also early attempts to research and manage the interactions between humans and their environment, and are discussed by Groffman and Likens (1994). A final example of how integration is currently conceptualized and operationalized is *Bioregional Assessments*, which are integrated assessments at especially large geographic scales. Below some examples of these various types of integration will be given, in order to facilitate a better understanding of what is meant by "integrated research" in a natural resource setting.

4.3.1 The Human Ecosystem Model

The Human Ecosystem Model (Machlis et al, 1997) contains several elements: *critical resources* (natural, socioeconomic, and cultural); *social institutions* such as the justice system or government; *social cycles* including individual and environmental variables; and *social order*, which includes elements related to identities, norms and hierarchies. This model is intended to be used both as an organizing concept for ecosystem management in large-scale areas, and to suggest social indicators for research. However, although this model is exhaustive in its list of elements that should be included in integrated research and management, this number of variables is far beyond what has been employed in either academic or agency research to this point.

The Human Ecosystem Model seems to be an academic exercise to explain the world that is observed, instead of a model which could be useful in the realm of integrated research as it currently exists. The amount of money and time necessary to structure a research project that included all of these variables is prohibitive in today's research environment. This model is useful, however, as a catalogue of variables which future researchers desiring integrated results could choose between, and as an early indication of some of the ways that integrated research may develop.

4.3.2 Integrated Ecological Assessments

Integrated Ecological Assessments as described by Lessard et al. (1999) specifically address the challenges that natural resource managers face in trying to integrate a variety of spatial and temporal scales. These models have tended to be more modest in terms of the number of variables which are addressed as compared to the Human Ecosystem Model (Machlis et al. 1997), but still attempt to assess relevant factors and conditions in broader issue focus or geographic areas. Resource managers have begun to use these types of evaluations because of a recognition that "traditional assessments have not adequately addressed the larger, ecological, social and economic context necessary for resource allocation or regulatory decisions" (Lessard et al., 1999). Some of the factors which are considered within these models are the inherent level of uncertainty within ecosystems, the need for "adaptive management" which learns from experimentation, and "social learning", which occurs as knowledge of human effects on the natural world expands. (Lessard et al., 1999).

According to Lessard et al (1999), integrated ecological assessments should provide: 1) descriptions of current and historic composition, structure, and function of the ecosystem; 2) descriptions of the abiotic and biotic events (including human actions) that contributed to development of current ecosystem conditions; and 3) description of probable future scenarios that might exist under changing conditions of climate, human use, and other factors.

Integrated ecological assessments seem much more likely to be implemented by researchers today, although a truly integrated research effort that comprises all these elements may require a great deal in the way of budget and personnel. Some early attempts to integrate human and biophysical variables in this type of model include: a study of the interactions between Mormon settlements, land degradation, national and regional water policies, and western range development and management strategies in the Little Colorado River region (Abruzzi, 1993); and models of simultaneous changes in land use pattern, economic activity, and function (Lee et al., 1992).

4.3.3 Integrated Regional Models

Integrated Regional Models (IRM) are another category of integration, one which attempts to use conceptual and mathematical models to link human decision making with biological interactions and physical environment (Schimel, 1994). Examples of these include models which use statistics to characterize relationships between soil erosion potential and farm practices, or population and deforestation (Liverman, 1994). IRMs related to forestry include those which model effects of climate change, pollution, or human development on change in forest type and distribution, as well as those which deal with economic questions such as yield of timber in relationship to human use and function of ecosystems (Picket et al, 1994).

4.3.4 Bioregional Assessments

Bioregional assessments combine agency policy interests with science and integration, albeit on a broad scale. Herring defines these assessments as "the effort to build knowledge about a region prior to decisionmaking and management action" (1999, p. 1). Examples have included FEMAT, the Sierra Nevada Ecosystem Project (SNEP) and the Interior Columbia Basin Ecosystem Management Project (ICBEMP). FEMAT brought together social, biological, and physical variables at the direction of President Clinton and resulted in the Northwest Forest Plan, which is an ambitious attempt to meet the habitat needs of an endangered species (spotted owl) while still allowing forest harvests at an economically viable level. SNEP and the ICBEMP were both efforts to fashion natural resource management plans for federal lands at bioregional scales. These types of projects vary in the approaches taken and variables considered, but all have explicitly attempted to bring the knowledge of differing disciplines to bear in an integrative manner on a complex problem.

In describing the context of bioregional assessments Johnson and Herring (1999) wrote:

> "Evolving questions and technologies seem to be pushing the boundaries of disciplinary science toward more integration among the biophysical and social sciences . . . . The context in which much of science is now conducted is increasingly collaborative, in part because the questions asked of science are increasingly complex. New technologies, which have allowed us to see connections among many systems at many scales, have prompted new questions about the consequences of change in any one of those systems" (p. 363).

The impetus for many bioregional assessments generally stems from policy problems, often accompanied by high levels of public and legislative scrutiny and short time frames. Johnson and Herring (1999) described the questions that these projects attempt to answer as the following:

> What do we have in terms of resources, economics, and societies of interest within the region?
>
> What is happening to what we have? (What are the trends of these things we have?)
>
> What might we do to fix any apparent problems, and what are the effects of the alternatives? (Develop options and evaluate their consequences.)

As the above examples show, integrated research is many different things to many different people. In the next section a general theory that underlies many of these research efforts is explored in order to more clearly explain how researchers define and view integrated research.

4.4 SYSTEMS THEORY

Systems theory has emerged in recent years as a viable framework for integrative research. Whereas traditional scientific methods involved reductionism and experimental analysis within disciplines, the new methodology is geared more toward integrative theory which combines "historical, comparative, and experimental approaches at scales appropriate to the issues" (Holling, 1998, p. 4). Janssen and Goldsworthy (1996) posit that several steps comprise analysis under the systems approach: 1) the interaction of the problem with other aspects of the system is expressed and described in a (qualitative or quantitative) model; 2) the model is then tested for goodness of fit; 3) solutions to the problem are identified and evaluated within the context of the model; 4) these solutions are validated and implemented. (See Appendix 3). Furthermore, an integrative science combines

> ". . . research and application, is interdisciplinary and faces the realization that knowledge of the system we deal with is always incomplete. It acknowledges that surprise is inevitable and there will rarely be unanimity of agreement among peers--only an increasingly credible line of tested argument. Not only is the science incomplete, the system itself is a moving target, evolving because of the impacts of management and the progressive expansion of the scale of human influences on the planet" (Holling, 1999, p. 2).

Systems are defined as a set of units or elements that are interconnected so that changes in some elements or their relations produces changes in other parts of the system. (Jervis, 1997). A further characteristic of systems is that the entire system exhibits properties and behaviors that are different from the whole. (Jervis, 1997). Systems are powerful structures and often display non-linear relationships, i.e., outcomes cannot be understood by adding together the basic units, and many of the results of actions are unintended. Systems theory therefore suggests that the degree to which separate biological and socioeconomic models can be integrated in an additive manner is probably extremely small. Other characteristics of systems which are relevant to integrative research include the ability of systems to self-organize and adapt; the existence of emergent properties in which characteristics of the system as a whole may be different from the parts (Murthy, 2000); and variations in stability and predictability at different stages (Gunderson, 1999).

Systems methodologies fall into two categories: hard and soft systems theory. Hard systems theory is the type described above; soft systems theory is more concerned with the ways in which people view systems. For example, in the field of forestry, hard systems theory might examine how biological elements such as species survival is affected by human variables such as land use, ownership patterns, and resulting forest fragmentation. Soft systems theory might examine how ownership attitudes toward species affected owners' willingness to undertake habitat restoration projects, as those who own their land for harvest purposes might have a different attitude toward the subject (and therefore a different effect on the system) than those who bought their land for environmental protection reasons.

Ison et al. (1997) reveal the relevance of soft systems theory to integrative research: "Systems analysis, and synthesis, seeks to reveal the different, and sometimes conflicting perspectives of stakeholders and to show that the many different ways of viewing the situation can be equally rational" (p. 260). Thus, any attempt at integrative research on large-scale systems must combine attention to the various views of the participants as to what the system is like with actual information on the system itself.

One of the strengths of the systems approach is that it acts to both combine disciplines and prevent researchers from branching off into more disciplinary challenges not directly relevant to the problems at hand. Single disciplines may research aspects of the problem, but adherence to a model keeps this research consistent with the overall goals of the project (Janssen and Goldsworthy, 1996).

4.5 INTEGRATED RESEARCH AND PARTICIPANT BACKGROUNDS AND WORLDVIEWS.

When examining integrated research efforts and what can be learned from the researchers who participate in them, it is logical to first explore what effect different backgrounds and worldviews of participants might have on the processes involved. However, because integrated research projects in natural resources involving both academicians and agency personnel are a fairly new phenomenon, little research seems to have been done in this area.

Although it does seem evident that academics may have a different view of integrated research from agency personnel, and that the training that each receives may be in some way responsible, it is difficult to find support for that premise in the literature. For example, there might be cultural differences which determine what makes agency personnel or academics credible. Agency personnel might be expected to be more concerned with meeting the agency management mandates, while academics might be more interested in doing "science". Another plausible difference that might be expected among participants could be related to the type and size of the project that they were involved in. Finally, the role that a participant plays in a project in terms of being an administrator versus scientist might also influence his or her perspective.

To examine the influence of personal backgrounds and worldviews on the ability of participants to engage in integrated research, a review was conducted of interdisciplinary research in academia, natural resource planning and management, and combined perspectives. For example, several texts have explored how biological, physical, and social scientists have evaluated attempts at integrated research in natural resources, and viewpoints from administrators and policy reviewers have also been included to a lesser degree in these texts (Johnson et al, 1999; Groffman and Likens, 1994; Gunderson et al., 1995). Some of this literature has evaluated larger projects such as FEMAT and the ICBEMP from the viewpoints of policy, science, and management (Johnson et al, 1999) or has evaluated the institutional and personal dynamics that affect attempts at integrated research (Gunderson et al, 1995; Knight and Landres, 1999; Clark et al, 1998; Janssen and Goldworthy, 1996).

4.5.1 Interdisciplinarity in Academia

Interdisciplinarity in academia has long been seen as requiring a change in the typical worldviews of individuals who participate in it. An early report from the Center for Educational Research and Innovation (OECD, 1972), cited the need for a "profound change in attitudes" necessary from those who participate in interdisciplinary research, one which combines "humility with open-mindedness and curiosity, a willingness to engage in dialogue, and, hence, the capacity for assimilation and synthesis." Interdisciplinary research further requires that representatives from different disciplines "accept teamwork and the necessity of searching for a common language," which tends to be anathema for those who have been trained in specific disciplines requiring individualistic behavior:

> "What is true for the majority of tenured professors is also true for a good many junior faculty members, who have fixed habits and prefer the easier alternative of not displeasing the "boss" and risking their careers on what seems to be a mere adventure, and thereby bolt down the system from one generation to the next . . . .The students might at least have been expected to be the best champions of interdisciplinarity. Experience has unfortunately proved that this is not so . . . . A good many of them have the vague sense that the institution needs changing . . . But once again, the "silent masses" have settled habits, a lack of

> information, structural inertia, a secret anxiety about the morrow and a fear of the unknown which have induced them to accept the return to the *status quo ante*" (OECD, p. 192-93).

Interdisciplinary work today also tends to be undermined by disciplinary work in universities, which reinforces social, political, and intellectual barriers to collaborative research. This has been changing, however, primarily through growth of new structures such as research centers and institutes; new university programs with an interdisciplinary focus; and projects which focus on certain categories or problems (Klein, 1990). Research suggests that more senior faculty members at universities may be more suited for interdisciplinary work, since they are more able to risk time out of the disciplinary mainstream and may be searching for new challenges. However, the worldviews of these individuals must be characterized by such traits as reliability, sensitivity to others, flexibility, and a preference for diversity and new social roles (Klein, 1990). Furthermore,

> "certain abilities have also been associated with interdisciplinary thinking: not only the general capacity to look at things from different perspectives, but also the skills of differentiating, comparing, contrasting, relating, clarifying, reconciling, and synthesizing. Since interdisciplinarians are often put in new situations, they must also know how to learn. They need to know what information to ask for and how to acquire a working knowledge of the language, concepts, information, and analytical skills pertinent to a given problem, process or phenomenon. We would know more about how individuals use these skills if we had more accounts of how interdisciplinarians actually work. Unfortunately there are very few accounts . . . " (Klein, 1990, p. 183).

4.5.2 Academic Work in Natural Resources

In the field of natural resources, multidisciplinary work in academia is seen as requiring several different worldviews. These include team members who are problem oriented and view their disciplinary job as a contribution to a main goal and respect the work of others; who can develop a common terminology and a minimum of jargon; and who are able to work well in a group. (Klein, 1990). Scientists whose backgrounds allow them to have broad analytical skills as well has clear disciplinary specializations are also seen as having an advantage. Furthermore, individuals whose worldviews encompass acceptance of constructive criticism, and who have the ability to debate and learn from other team members, yet not be overwhelmed by the friction of those debates, are better able to function on interdisciplinary teams (Janssen and Goldworthy, 1996).

Another factor in the worldview of participants in interdisciplinary research has to do with how important it is to them to publish articles in scholarly journals. If individuals are just starting out in their career and need to achieve tenure, they may be discouraged by the lack of interest many disciplinary journals and research funding agencies have in multidisciplinary work. However, there are journals that are beginning to focus on the results of multidisciplinary work, and an outlet for jointly written reports on this type of project can usually be found. At least one recent journal article also cites the greater sense of accomplishment that can be found from working on a successful multidisciplinary team, and believes that this can compensate for "not seeing one's name in print as often as one would like" (Janssen and Goldworthy, 1996).

4.5.3 Combined Agency/Academic Integrated Research

Beyond the world of academia, integrated research involving both academicians and natural resource management agency personnel has rapidly grown in the last decade. The backgrounds and worldviews of both scientists and land managers therefore have important consequences on the success of this type of project. Resource managers are becoming more involved in research, and scientists are increasingly involved in helping to design management prescriptions and technologies (Clark et al., 1998). In order to work together on integrated research projects, both categories of professionals must become more comfortable with the history and practice of the other. Those individuals with a scientific background may find this more difficult, given the emphasis that science has traditionally placed on the distinctions between those who qualify as scientists as those who do not (Gieryn, 1983). Furthermore, forces intrinsic to both of these groups, from conflicting goals and resources, different traditions and norms, and limited resources, may interfere with the possibilities for collaborative, integrated work (Yaffee, 1999).

Many managers may feel that their role as directors of agency activities is diminished by their participation in joint research efforts with scientists, especially if they are based on either scientific issues or legal and political challenges.

Furthermore, when research is policy-driven, the traditional scientific paradigm and viewpoint may be challenged by little control over the agenda; difficulty in getting the information that is needed; having to deal with legal and policy challenges; and the necessity for having scientist work scrutinized by non-scientists using different methods and standards for judgement (Clark et al, 1998). Thus, a scientific background may produce individuals who have difficulty in functioning in an environment in which there is strong government control of both the policy /research agenda and the purse strings for projects.

The scientific viewpoint also tends to have different traditional objectives than that of natural resource managers. Scientists are usually striving for general understanding of an ecosystem within a narrow disciplinary focus, combined with plans to apply the new understanding to large geographic areas and long time frames. Alternatively, managers tend to be responsible for specific pieces of land within an ecosystem, and typically want to understand the managed landbase first, with an emphasis on broad based learning only if it furthers this goal (Borman et al, 1999). Managers may also prefer doing "just-in-time" science, which is science "that is ahead of management, but not too far", in contrast to scientists who are often interested in variable and processes in the long-term (Clark et al, 1998).

Scientists and managers may be able to find common ground when scientists come to accept that management is a dominant ecosystem process, and managers realize that the increased information and analysis provided by science are necessary in order to better manage their land areas (Borman et al, 1999). For example, fire suppression has led to altered ecosystems throughout much of the country. The current management swing to remedy the consequences of this ecosystem changing management philosophy is modifying these landscapes even further.

However, other dominant viewpoints related to perspectives in the two fields may still interfere with the ability to do integrated research. What has been termed the "technical rational" viewpoint is emphasized in much of science, and has characteristics such as reductionism (which assumes that complex problems can be understood in terms of a few variables abstracted from their original context); reliance on models and data generated by the scientific method; the assumption that the researcher is objective; and quantification of information, often with little regard for individual differences (Lang, 1990).

Managers, on the other hand, may see the world from more of an organizational perspective, and this can also interfere with the possibilities for collaborative, integrated research. This viewpoint perceives everything in terms of its effect on the organization, and survival and stability of the organization and achievement of its goals can be paramount. Institutions such as agencies are also often plagued by inertia, and narrow objectives, short time horizon, and a strong fear of failure may also accompany public land management agencies (Lang, 1990; Shindler et al., In press).

4.5.4 Social Scientists v. Biophysical Scientists

Another difference in backgrounds and worldviews that might be important in integrated research efforts are those of social scientists and biophysical scientists. Generally the biological and physical sciences place a much heavier emphasis on the scientific method and quantification, while the social sciences include much in the way of qualitative, exploratory research, with attendant measurement and uncertainty problems (Berk, 1994). Social scientists may stress the need for biological scientists and land managers to take into account the "social content" of the ecosystems they study and manage by understanding the viewpoints of local people, and by exploring the values associated with the lands (Parker, J. K., 1999). For example, individuals and groups may attach meaning to lands they interact with as homeowners, as indigenous peoples, or as those dependent on the resources in an ecosystem for their livelihood.

Final factors related to background and worldviews of individuals involved in integrated research projects may have to do with the types of projects in which they are involved. Those individuals who were involved in larger projects with longer timelines may have different views than those who participated in smaller, more focused projects. Those who participate in more traditionally scientific projects may have a different viewpoint than those who participated in policy driven projects. Little comparative research has been done in this area, however, given that these types of projects are fairly new in the field of natural resources. One model that has emerged relates to the division of responsibility between scientists and land managers/policy makers in different types of bioregional assessments and may shed some light on this topic (Johnson and Herring, 1999). (See Appendix 4).

In the Johnson/Herring model, the roles of a scientist can vary from that of a "philosopher-king" who assesses the situation and develops a management plan, to that of a "bystander/critic" who simply critiques plans developed and evaluated by policy makers and land managers. Different types of projects have followed different strategies and this model addresses the effect of the role of the scientists on the chance for "wild science" within a project, the scientific credibility of the project, the time needed, and the support from land managers. Beyond the effect on the project as a whole, scientists who take on the role of a "philosopher-king" may have a different definition of integrated research and processes than those in other roles; the same may be true for land managers who have assumed different roles in integrated projects (Johnson and Herring, 1999).

When scientists have a role in framing the policy questions and conceptual framework for an analysis, the project may also be designed around the expertise areas of the participants. In the oft-quoted proverb, everything looks like a nail when all you have is a hammer. If a wildlife biologist is in charge of designing a project it may become a question of habitat and species sustainability, whereas a silviculturalist may see improved timber harvest levels as the preferred outcome. If a variety of scientists come together for an integrated assessment, the process of compiling and synthesizing information may be far beyond their previous expertise as individual scientists. They may have to deal with a variety of time scales and methodologies that cannot easily be matched up, as well as have unfamiliarity with other disciplines. When this is the case, critical questions may be raised concerning the credibility of "analyses over vast scales using data sets from a variety of sources and protocols" (Johnson and Herring, 1999). Thus, the disparate backgrounds and levels of experience of project participants may also have a considerable effect on an effort to conduct integrated research.

4.6 BARRIERS TO INTEGRATED RESEARCH

Many different barriers to integrated research are cited in the literature, including those related to disciplines, roles of individuals in projects, and funding.

4.6.1 Barriers between Disciplines

As discussed in the section on interdisciplinary research, over time disciplines have evolved their own cultures, languages, methodologies, and value systems. Therefore, disciplinary barriers to integrated research can range from lack of a common language to differing worldviews and values (Pickett et al, 1994). Biologists, for example, can come into a project with a focus on how specific species are affected by the management policies to be examined, whereas those in the socioeconomic disciplines may see the question in terms of how it affects the yield of timber or economic viability of timber-dependent communities (Gunderson et al, 1999). Unless individuals have experience in working outside their disciplines, it is also likely that terminology will be an issue.

On larger projects, the types and number of disciplines that are attempting to integrate their work may also be of importance. A high degree of diversity of disciplines can magnify the problem in understanding language and professional norms (Janssen and Goldsworthy, 1999). Murthy (2000) describes the need for a "meta-language" when dealing with complex systems research: "The description of complexity requires a chosen language to embrace the inherent grades and shades of ambiguity in the subsystems, elements and the relationships which are the exchange processes within the system as a whole" (p. 76). Thus not only is there a lack of language between disciplines, but there may also be a lack of a common language for that nebulous area where integration is supposed to occur. This lack can include unclear definitions and expectations, lack of common paradigms, differing languages to say the same thing, and the difficulties involved with merging different disciplinary approaches to problems and methodologies (Clark et al, 1999).

Which disciplines and individuals to include in integrated research may also be of importance to the success of integrated projects, and these selections may also impact the research itself. These choices are frequently based on the specific policy or question to be addressed, the availability of scientists, or because the individuals involved have characteristics deemed important for integrated research efforts (Franklin, 1999; Johnson and Herring, 1999). As more disciplines are included in a project with greater diversity among individuals, the more difficult successful integration becomes (Johnson and Herring, 1999).

4.6.2 Roles in Project as a Barrier

Another possible barrier to integrated research is the differing roles that individuals have in projects, from those related to administrator vs. scientist to those involved with agency vs. academic roles. For example, agency managers (who are often trained in the biophysical sciences) may not know how to use information brought to them by human dimensions researchers (often academics), and these researchers in turn often do not understand the social/political decisionmaking environment of the agency (Giglotti, 1998; Bormann et al., 1999). Furthermore, university and agency personnel are motivated by different factors: university faculty work toward publication records and development of theory, while agency personnel may have more interest in solving problems and demonstrating a record of service (Gigliotti, 1998).

A related barrier involves the possible lack of support from superiors in agencies for collaborative work. In a recent study respondents cited "lack of support from upper levels of management" as a key barrier to Forest Service employee participation in cooperative projects (Yaffee, 1999). A similar barrier within academia has to do with a merit system that traditionally has rewarded individual, disciplinary achievement but until recently has thought less highly of collaborative work. Journal articles for collaborative work may be harder to come by, interdisciplinary research funding scarce, and peer review tenure committees may not value these publications as highly (Pickett et al, 1994).

Lack of respect and understanding between social and biophysical scientists may also be a barrier to integrated research. Field (1996) states that "the view that social science is a so called 'soft science' lessens the stature of social science . . . " and credits this lack of stature to both institutional issues in research and development, and the failure of social scientists to clearly communicate the relevance and results of their work. Many of the most widely cited sources on ecosystem management also fail to include the scientific contributions that can be made by political scientists, sociologists, anthropologists, and other social scientists (Endter-Wada et al, 1996).

In addition, differing paradigms and epistemologies may interfere with the ability of scientists from social and biophysical realms to interact. According to Endter-Wada et al. (1996) natural scientists may be more concerned with preserving natural resources from human "intruders", while social scientists may perceive ecosystems as providers of goods and services and focus more on their use value to humans.

4.6.3 Funding Issues

Funding barriers also may affect attempts at integrated research. Many authors have noted the lack of funding for integrative research (for example, Picket et al, 1994; Johnson et al, 1999; Clark et al, 1999), as well as how specific requirements attached to funding for integrated projects affect the degree of integration possible (Johnson et al, 1999). For example, the mandates attached to funding for FEMAT may have lessened the extent to which the project could be truly integrative. Although FEMAT tried to resolve the legal and scientific debates surrounding the old growth/spotted owl issue, it was unable to adequately address the human value dimensions of the underlying debate (Nelson, 1999). Instead the decision framework used "became a simplistic trade-off between timber production and species protection" (Nelson, 1999, p. 122).

4.6.4 Leadership and Team Composition

The literature cites leadership and team composition as other factors important to the success or failure of integrated research efforts. While many authors have touched upon the qualities necessary in leaders for integrative projects (for example Johnson and Herring, 1999; Janssen and Goldsworthy, 1996; Webster, 2000), these same authors make it clear that individuals with these qualities are somewhat rare. For example, Webster (2000) cites the need for leaders who are committed to excellence and have an ability to set high standards, and who have both strong knowledge in the subject area as well as the ability to synthesize and see the big picture. Additional leadership qualities this author deems necessary include intellectual curiosity and a vitality for learning across disciplinary boundaries; a willingness to take risks; an ability to stimulate all collaborators to ask questions and to re-examine deeply held assumptions; and a strong appreciation of the importance of collaborative research.

Other lists of qualities necessary for leaders of integrative research projects are equally as daunting. Leaders should be "powerful and respected" and be able to communicate with and have the trust of managers, policymakers, and team members (Johnson and Herring, 1999). Furthermore, individuals who seek to build bridges between disciplines should have established credibility in their own field and be able to foster interdisciplinary exchange (Waring, 1998). Leaders should therefore participate in cross-disciplinary workshops and conferences, and read outside their own field as the means to foster this type of integrative perspective. (Waring, 1998).

Janssen and Goldsworthy (1996) argue that team composition and the ability of scientists to integrate successfully are equally important to the success of integrated research. For example, scientists must be able to actively participate in brainstorming session, possess the ability to overcome disciplinary limitations, and be willing to make one's own research plans fully contingent on the plans of the team. Alternatively, individual shortcomings or personal bias among team members can interfere with the success of integrated assessments. Researchers may refuse to accept some kinds of knowledge as legitimate or see them as being wholly within the domain of either biophysical or social science, thus precluding an integrative approach (Pickett et al, 1999). Scientists may also lack social skills necessary for working with others, have ego problems, be deficient in the ability to communicate effectively, or have little understanding and concern for others' needs and interests. Other personal qualities that may pose barriers to integration include hidden agendas, overriding ideologies or prejudices, and distrust of others (Clark et al, 1999).

4.7 FACTORS AFFECTING THE OUTCOME OF INTEGRATED RESEARCH

In this section, the factors cited in the literature which affect the success or failure of integrated research are discussed.

4.7.1 Different Definitions of Integrated Research

Several different elements are cited in the literature as having a significant impact on integrated research. First of these is the differing definitions which may exist about what exactly integrated research is. Clark et al, (1999) report that not only do differing definitions of integration exist, but it is unlikely that a single, uniform definition will emerge. For example, researchers may see integration as involving different viewpoints on the same problem; as encompassing coordination between agencies or disciplines; or as working as a team on a model (Lessard et al, 1999). It may therefore be necessary for those attempting integrative research to determine which elements of integration are necessary for achieving the answers that they seek. Furthermore, the advantages and limitations of various approaches to integration should be clearly understood by the researchers who are doing the work; this may be difficult given these different possible definitions (Johnson and Herring, 1999).

4.7.2 Context and Scale

The context of an integrated project as well as its geographic and temporal scales also affect attempts to do integrative research. In reviewing the literature it became obvious that not only is the effect of context on projects important, but how context is defined by those involved also has a good deal of impact on the outcomes. (Shindler et al., 2000). This section will first examine how context is defined and then discuss how these various conceptions may affect the scales at which projects are undertaken..

Research context can be defined in several different ways: from the political/policy arena in which the research takes place to a geographic area; a specific problem to be solved; or the way in which the problem is perceived. Literature on the "context" of research projects can include all or one of these factors. Context may also include "the dominant theories in science, current resource management practices, and the values imbedded in public policy" (Johnson and Herring, 1999, p. 342). For example, bioregional assessments often take place in the context of a natural resource management or policy crisis, which may have a great deal of effect on who oversees and controls the research, how it is perceived and funded, and the outcome expected within a certain time frame (Johnson and Herring, 1999).

Other integrated research may target changing values of local communities or the society as a whole, thus this context may affect what the information expectations and preferred outcomes are (Lessard et al, 1999). If the values of local communities are what researchers are attempting to learn about, then the context of their study might be a survey of local attitudes in meetings. Alternately, if a study is broader in scope, with a need to understand societal values for a natural resource or course of action, then statistical analysis of survey data may be the preferred outcome. Thus, the type of information gathered and how this data is analyzed can form part of the context of the research.

The contexts researchers consider and include within integrated research projects are also important, and may vary from project to project. For example, Reed and Mroz (1997) delineate between the physical, biological, and social contexts in which ecosystem management and integrated research assessments take place. These may include elements such as vegetative community, hydrology of a region, and social mores and values of local communities. A further element of context may also be the way in which management professionals and academics think about the natural resources they are attempting to study or manage in an integrated manner. These individuals often understand and represent elements of ecosystems in ways different than local people think about the same things, and this can affect the extent to which findings can be generalized and applicable. (Parker, 1999). The context of integrated research can therefore include differing types of worldviews that may or may not affect how the research itself is carried out.

Context for the particular integrated projects used in this study included the political arena in which they took place and how that affected the way the research was carried out, how important issues of the day such as the salmon crisis in the Pacific Northwest impacted the direction of the research, and how the institution in which the research occurred influenced the type and direction of the research (Johnson and Herring, 1999; Clark et al, 1998).

Scale of a project and the way that scale is defined also have an impact on integrated research projects (Johnson et al, 1999; Gunderson et al, 1995). The effect of scale can be related in both temporal and spatial terms to the project itself, or it can be defined in terms of how the research itself must be carried out. In the latter category examples include how to match the faster temporal scales related to social variables, such as population growth, with slower biological variables such as growth of species of trees or over what period measurements are made (Holling, 1995). Spatial scale has to do with the breadth of the geographic area being studied in an integrated research project. As an example, the ICBEMP studied an area of approximately 144 million acres, and the size of this assessment area is seen as having a large impact on the type of research done and the degree of integration achieved (Johnson and Herring, 1999).

Likewise, the temporal scale of a project can include the amount of time that is involved in the research and the integration process. Two contrasting examples of the effects of time on integration can be seen in FEMAT (which was accomplished in a period of months) and the ICBEMP, which took nine years and is still in the process of revising the Environmental Impact Statement that came out of the project. Temporal scale can also refer to the differing time frames in which elements of ecosystems function and interact. Some biophysical elements of ecosystems may be measured from year to year (for example the amount of timber produced) whereas social elements may take much longer to measure. A major challenge to those conducting integrated research is finding a way to bring together elements of ecosystems which function on different time scales (Pickett et al, 1999).

When examining scale it is also important to recognize how research at an ecosystem level might be carried out. Ecosystem research and management, by definition, takes an ecological approach across multiple temporal and spatial scales, and scale properties are seen as being highly relevant to understanding the interrelationships between components (Lessard et al, 1999). Therefore the definition and effect of scale on a project may be related to the importance of questions being tailored to the appropriate scales, resolutions, and hierarchies of ecological organization in an area (Swanson et al, 1997).

CHAPTER 5

FINDINGS AND DISCUSSION

5.1 INTRODUCTION

Previous sections of this thesis described the research questions that were generated for this study and the literature that supported them. Based on the content analysis approach to organize emergent themes, findings from the interview portion of the project are described and discussed here. Because of the exploratory nature of this project, it is important that specific ideas and observations of the interviewees be highlighted for future research purposes. To that end, direct quotations from project participants are liberally used as illustration of these ideas.

An important aspect of cross-case analysis is a recognition and reconciliation between the experiences unique to one case as opposed to the need for an understanding of what themes can be generalized between cases (Miles and Huberman, 1994). In order to best illustrate findings and analyze the results given this dynamic, the following sections are first organized around the research questions and general conclusions from the interviews.

Important subsections will be presented under the research question headings, and each of these subsections will contain the categories which seem most appropriate around which to frame conclusions. For example, in some categories the most noticeable similarities or differences of opinion occurred around the disciplines that the interviewees were associated with and those categories will be highlighted where appropriate. In other research areas, the type of project or category of project (for example bioregional assessment vs. smaller integrated project) seemed to play a larger part in the answers given; these categories will be emphasized in this circumstance.

5.2 DEFINITIONS OF INTEGRATED RESEARCH

The broad research question for this section asks how integrated research is viewed by those who participate in it, and whether differing definitions of integration exist. The question further asked whether these definitions differed depending on type of project, and if so how?

5.2.1 Areas of Definitional Agreement

Although definitions varied when interviewees discussed their particular project, there did seem to be a surprising degree of agreement on several aspects of the definition of integrated research given the suggested lack of a singular, cohesive definition postulated in the literature review. This might be attributed to the sample used in this thesis--for the most part the individuals interviewed had extensive experience in integrated work and therefore perhaps tended to have thought more about what was included in integration. Another aspect of this could be history: as individuals have participated in these types of projects, their definition and understanding of what integration is has evolved and become more sophisticated.

5.2.2 The Importance of Integrated Questions

Almost all interviewees agreed that integrated research involved more than just bringing together various disciplines on a project. Most individuals interviewed mentioned that there had to be some sort of integrated question or questions at the beginning of the project around which the research would be built. These types of questions were usually so complex that one or even a few disciplines could not adequately address them.

> *"Integrated research has to start with integrated questions, and a lot of that has to do with how these questions get framed. A researcher I knew once said that 'it is really interesting, we have this tremendous focus in our educational processes and in our organizations about developing problem solving abilities and being good problem solvers. I think that we would be very far ahead if we tried to be good problem posers'."*

> *"It is important to phrase problems right, before you go on to solve them. One of the quotes I use is 'Severied's rule': the cause of most problems is solutions. I use it in groups and when I first put it on the overhead people start laughing and then people start nodding. We don't have very good places and forums to problem frame."*

Two individuals pointed out that unless good integrative questions are framed at the beginning of projects, the conclusions reached by these projects are very unlikely to be integrative.

Several interviewees who were involved in the initial phases of their projects described situations in which the initial focus was not so much on integration but on a question whose complex nature demanded an integrated approach. This type of question usually also required the use of approaches and tools which were not available within any one discipline. Despite this agreement, however, a few individuals felt that integrated research could take place within one discipline as long as the researchers were looking at a variety of components of an ecosystem.

"Integration is when you see how different components of the larger system help better explain the function of the whole system. It has more to do with the question being answered than it does with involving different disciplines."

"Integration is research in which a variety of disciplines are needed to address a scientific problem. Other scientists tend to sometimes view integration as getting a bunch of scientists together to give advice to policymakers on the state of knowledge. While that is integration and involves a variety of disciplines, I don't call it integrated research because it is not testing hypotheses."

"People don't explicitly think about integration a lot in the management arena, and integration tends to be in the eye of the beholder. It can be multiple disciplines working on a project, but many times this just turns out to be just everybody doing their own thing. Integration is jointly defining questions and methods, working together to make sure that things are implemented as correctly as possible, and then working together on an analysis of the results."

5.2.3 More than Just the Sum of the Parts

Another definition of integrated research most interviewees agreed upon was that the whole of the project had to be more than just the sum of the parts. Several different individuals interviewed used the phrase "more than just stapler science" to describe the difference between an integrated project and those in which various reports from different disciplines were simply stapled together at the end of the project. It was also notable that most interviewees used the word "system" to describe the object of their research as opposed to simply discussing their part or disciplinary contribution.

"If you are really going to do integration, it is not an add-on, it has to be a way of looking at the world. Integration tends to work if you are all working on the same thing, like building a model."

"Not everything is integrative or needs to be integrative. The first clue is what the problem is that you are trying to solve. If it is very narrow then you may not need integration. When you are trying to solve problems that are very complex then you are more likely to need an integrative approach."

Another interesting finding was that although many individuals interviewed tended to define integration in much the same way, these same individuals felt that most other researchers defined integration with essentially the "stapler science" model. Interviewees seemed to feel that other researchers they had been involved with defined integration differently than they did, and that these researchers did not truly understand what real integration was.

5.2.4 Making Sure that the Parts Fit Together

Several individuals defined what integration was *not* by describing situations in which the pieces of a project were not crafted in such a way that they could fit together. Others cited situations in which the lack of clear integrated questions resulted in the pieces included being those of lesser priority (or not the most important ones) influencing the way that the whole system worked.

"One thing that you need is a good idea of what the final product will be. If you know what the final product is going to look like then you have a much better idea of what the pieces need to look like to fit into the adjacent piece of information. You have to take into account the scale and other characteristics of each component that will allow it to successfully integrate with the other components of the project."

One scientist described two different situations that she had been involved in while trying to do integrative work. In the first situation, the individuals involved had worked together as a group for almost the entire duration of the project. They defined the questions together and then figured out ways in which all the aspects of these questions could be answered by sub-groups. In the second example, sub-groups were formed at the beginning of the project in a bid for efficiency, and then each went off and did its own work. However, when the groups came back together to attempt to write a report on the problem it was discovered that each of the groups had questions for the others which they could not answer. In essence, the groups did not collect the right kinds of data to answer the questions of the other groups, and thus the question as a whole was not addressed. Each group gathered the type of data that they had decided was important, but had not considered what the other groups were working on or correctly identified what other groups might consider most important. One of the conclusions that this scientist reached was that if researchers come together at the beginning of an attempt at integration they are more likely to include questions that they might not otherwise consider.

Another aspect of integration that many interviewees seemed to agree upon had to do with several subsets of the definition of integration. Scientists described attempts at integration as taking place in one geographical area (for example, the HJ Andrews) or as involving different tasks given out to different individuals in order to build a model together. One scientists referred to these categories as "spatial integration" and "task integration", and contrasted them with "true" integration, which he described as integration of ideas. Another oft cited idea of integration had to do with its integration as a process, not as an end or an outcome.

"The idea of what integration is has changed over the last 13 years. Initially when I thought about integrated research and management, I thought about an end product, managing a landscape for a multitude of uses, both consumptive and non-consumptive. My view has evolved considerably and it is clear now that when people are talking about integration they are talking about a process, not an end product."

5.2.5 Did Projects Achieve Integration?

The types of projects that individuals were involved in also had an effect on their definition of integration. It was interesting that those who had been involved in larger projects such as FEMAT and the ICBEMP tended to feel that the outcomes of their projects were much less likely to have achieved integration, whereas those who had been involved with smaller projects seemed to feel much more comfortable that their project fit within their definition of integration.

In terms of individual projects, there was some disagreement as to whether FEMAT could even be termed integrative research. Many scientists pointed out that since FEMAT essentially relied largely on secondary data and therefore did not conduct new "research" it did not fit within the definition; however, several scientists who have had extensive experience with integration took issue with this viewpoint. This second group pointed out that FEMAT did achieve new *knowledge* and thus could be considered integrated research.

Most individuals who participated in the ICBEMP seemed to feel that the implementation of the project resulted in its results being less integrated than their definition required.

"The landscape ecologists went off on their own and determined what they thought were the important variables. When the rest of the teams were asked to develop scenarios which they spent two days doing it, but when the landscape ecologists came back they said 'we can't use any of these, because none of these variables were in our model . . . . So if the basic structural model is developed by only one discipline, then there are going to be problems with integration."

"Fish management in the Interior Columbia Basin was regarded solely as a biological problem, not a social question at all. But you have the four H's: habitat, hydropower, hatcheries, and harvest, and all four of those things are humanly derived aspects of the problem . . . . But those things were viewed solely as a biological problem, so I don't think that there was integration in that aspect of the project at all."

Individuals involved in the smaller projects such as COPE, CLAMS, and CFER seemed much more comfortable that their projects fit within their definition of integration. However, it should be noted that these projects did not attempt to integrate social variables to the extent that FEMAT and ICBEMP did.

Individuals across projects almost uniformly agreed that their projects failed to achieve their definitions of integration, and were very forthcoming in the ways in which they felt that this was so. However, one of the interesting dichotomies was that the majority of those who felt that their projects had achieved integration were administrators; whereas most of the scientists on these projects had much less confidence that the level of integration achieved fell within their definition.

Interviewees who had participated in more than one project also described a "learning curve" in which definitions of integration grew and expanded as individuals gained more experience.

"There is definitely a learning curve when it comes to integration. CLAMS is built on FEMAT, on the LTER effort, and on COPE. It's built on my experience on a Forest Service project in which there was a huge effort among scientists to synthesize information about vegetation and wildlife of natural forests. On every project you learn what you should have done."

"Integration is hard *and that is why most projects don't really do it, despite everyone talking about it. Integration is like learning to live in another culture. You have to learn another language, you have to learn to be aware and be sensitive and appreciative of often very different worldviews, you have to have a capacity to explain yourself in ways that are intelligible. And there is a natural tendency to think when you're listening to other people, 'How did they get so screwed up?' And they are probably thinking the same thing about me. That's what takes the time—becoming sensitive to each other."*

5.3 DECISION MAKING IN INTEGRATED PROJECTS

In order to more fully explore what the five case study projects entailed and how they differed, respondents were also asked to describe how decisions were made about what disciplines to include in their projects and what the end result of this selection process was. Necessarily the sample size for this question was smaller, since many interviewees did not participate in the original decision making process.

One of the most prevalent responses of interviewees was that the disciplines and processes chosen for inclusion largely were a result of the question(s) that were to be answered by the project. If the project was intended to answer questions related to human/environment interactions at a broad scale, then disciplines related to these factors would be considered for inclusion. If the project was just designed to look at the interface between forests and riparian areas then disciplines related to this goal were the ones important to include. Several individuals felt that it is necessary to keep a balance between various factors important to the success of projects.

"You have to keep a balance between pushing the envelope and doing new and exciting things, and keeping things from spiraling out of control. It is necessary to consider how many pieces can be included in a project at one time in integrated work, and seek a balance between the vision of the project and the practical considerations. You also have to make sure that the vision for a project is accessible to the participants and the observers. So there needs to be this balance when deciding what to include in a project."

One factor that was uniformly cited for its effect on the decision making for these projects was funding--the diversity and number of disciplines that could be included in a project was directly related to the amount of money available. A comment made about FEMAT and projects of its type (i.e., those involving synthesis of existing knowledge) is that these could be done for much less money. FEMAT and ICBEMP also had funding which was tied to specific political goals and situations, and national politics had a great deal to do with which disciplines were included in these efforts. Often the social scientists interviewed felt that inclusion of social variables is still an afterthought despite the emphasis placed upon them in the political arena.

"Funding is often more of a problem on the social science side than the biophysical science side. Often social science is an afterthought, and social scientists are told 'we want you to do X,Y, and Z and here's fifty thousand dollars to do it."

Several scientists also cited the way in which the problem is viewed by their superiors as a factor in decision making about integrated projects. For example, because President Clinton saw the FEMAT process as a way to bring about solutions in the Pacific Northwest to address both human and biological needs and mandates, the project had to include these components.

"You have to focus on some key questions and then be open to modification along the way, both from information that you get and from the response of the stakeholders. When you get more money, you add more components to the study. I usually start with two lists—one for the land managers and one for the scientists—of what is at the top of their interests in doing. I look at the priorities of the two, try to match them up, and then see who is available."

The COPE project was similarly the result of a call from many different parts of the forestry community in Oregon (state, federal, private) for research that would help them to better integrate management of forests with species and riparian issues. This general structure was proposed to the federal funding agencies and once the funding was secured meetings were held in various coastal Oregon towns to ascertain the types of forestry issues these types of communities were trying to deal with. An advisory council was formed from a broad and diverse base of individuals and stakeholders, and this council helped establish the research agenda and also helped determine which disciplines should be involved in the project. In this particular case, the views of stakeholders had a broad effect on which disciplines and processes were included in the research effort.

When a project is relying on the grant process, the issues seem to be slightly different. Often the granting agency will specify which types of disciplines should be included or to simply refer to inclusion of "biophysical and social disciplines." Sometimes the process involves convening scientists from various social and biophysical fields to discuss the types of relevant research and how these might fit into the overall project.

Another even more informal method whereby integrated projects come about was described by one interviewee as *"two scientists from different disciplines who get together at a conference or meeting and discover that they have a common question of interest."* These scientists write a grant proposal and then get a couple of graduate students to work on the question. If the project turns out well then the students can build their career on the research and the science can evolve over time.

Evolution of ideas is an additional way that integrated research projects come about. For example, the CLAMS project was the result of issues that evolved during COPE and FEMAT. Several important issues such as the effect of land ownership patterns on species were not adequately addressed within those projects, and some project participants felt they needed to be further explored. These individuals decided to bring together individuals who could conduct research on such questions.

When interviewees were asked how they went about choosing individuals for their projects, some interesting answers emerged. One scientist who had been involved in several different projects described it as deciding on which disciplines and sub-disciplines to include and then "calling your friends." This interviewee defined these individuals as people you can trust and who have high levels of integrity.

"In FEMAT we eliminated a lot of people because we thought they were destructive. You don't want a grenade thrower in there in the temple with a bunch of scientists who are trying to construct something."

"You need people that you can trust; trust is really important. Kind of like someone you would choose to go rock climbing with. Someone who has a high level of integrity."

5.4 DIFFERENCES IN BACKGROUNDS/WORLDVIEWS

The second major research question for the study attempts to discern how differences in backgrounds and worldviews of project participants affect their views of integration and their participation in it. Despite the areas of agreement outlined above, there were noticeable divisions between individuals with different backgrounds when it came to a definition of integrated research.

5.4.1 Disciplinary Differences and Integration

One of the clearest divisions occurred between social scientists (excluding economists) and biophysical scientists. Social scientists were much less likely to feel that meaningful integration had taken place on their projects. This seemed related to the idea that their definition involved much more of an inclusion of social variables into integrated questions than did the definitions of biophysical scientists, and the fact that social science has often been an add-on instead of part of projects from the beginning.

"A lot of projects that label themselves as integrated are not—they are interdisciplinary. Integrated work is necessarily interdisciplinary, but interdisciplinary work is not necessarily integrative. What a lot of projects try to do is have the economic role serve as a surrogate social science component, but that is a very conventional, very narrow conception of what integration is. A lot of times this is because projects are simply the 'old boys' trying to do the same thing that they have done in past projects, and I am very skeptical when I hear them talk about their 'integrated project.'"

"I don't know why there wasn't involvement of social scientists in issues like anadromous fish in the ICBEMP. The subject was assigned to the Riparian team and when I objected and said that it seemed to me that this was also a social scientist problem I was told that I was not to get involved in that."

Although there did seem to be some genuine acknowledgement on the part of many biophysical scientists that an encompassing definition of integration would have to include social variables, there also seemed to be many excuses for not doing so. For example, one biophysical scientist described a situation where lack of funds prevented inclusion of much of a social component in the integrated project. However, this scientist genuinely seemed to feel that asking and answering integrative questions was entirely possible without this inclusion, especially when these questions were tailored to be more narrow in focus.

Social scientists were much more likely to question whether it is even possible to answer integrated questions about an area or an ecosystem without attention being paid to human factors such as political context and institutions, public values, and human use and expectations. Social scientists further tended to be very skeptical of the more traditional viewpoint of integration, that inclusion of an economic component handles all the human factors pertaining to the questions about an area. One social scientist said *"I look at these projects and say 'if this is* *supposed to be integration then where is your social component?'"* This also goes back to agreeing on the research questions--social scientists felt that unless you were including the social component you were not asking the right types of questions that lead to integrative answers.

5.4.2 Professional Backgrounds and Integration

Another interesting facet related to disciplinary background had to do with the views of land managers vs. those of scientists. One interviewee who has had extensive experience with both defines integration as trying to find ways in which scientific projects can help management and vice versa. His view of integration also involved trying to find parallel objectives for these two very different communities who held different views on how the world works. Another interviewee described how land managers were left out of the FEMAT process.

"Integration is more than just going across disciplines, it is also doing projects across management/science boundaries, and trying to see how science projects can either answer management questions or how science projects can pose or bring forth new ideas for management."

"One of the problems with the Northwest Forest Plan was the exclusion not just of the public from the process, but also the exclusion of the land management organizations. They were shut out very purposefully; the door was closed to them because nobody trusted them. One of the growing senses of the problem was that the management organizations had become so disenfranchised of the public trust that you didn't want them fiddling with the project. But then you had the irony of having this plan that was then turned over to the managers to write the EIS and implement it. If we had to do it again, I would include both managers and citizens, and first spend some time trying to figure out what it is that we were trying to do."

A couple of interviewees were very graphic about the differences between managers and scientists on the ICBEMP, and thought that difficulties in these relationships were one of the major problems with the project.

"There were huge barriers in our project between managers and scientists. Because the scientists were high status, you know, 'back off man, I'm a scientist,' while the managers were these mendicant, groveling in the dirt low lives who didn't have the credentials or the wherewithal to ever do anything right. So there was this huge kind of class difference between the two groups. It was pathetic. . . . It was really an artificial construct, the division between the two. You were working on one project, but you were artificially divided. It created all these status problems; it created all this enmity between the groups, but worst of all, they only got people in the management group who didn't have a job somewhere else. The Forest Service was responding to budget cuts at the White House, and the timber harvest volume just plummeted so there were thousands of Forest Service employees who were out of a job. So the topic of conversation everyday at work was 'who is on the surplus list; who is not wanted; who is extra around here.' So you had people on the management team who had absolutely no skills whatsoever. We had one guy who was supposed to be the facilitator of these public meetings, and he was a silviculturalist. He had not a clue; he was one of the poorest communicators I have ever seen in my life. It was so sad for this poor man. It was like telling a social scientist like me to go out and design a gravel road on a mountain, and would I ever fail at that. So we put people in these awful positions because they didn't have any other jobs."

"We had one of the worst groups of managers that I have ever worked for in my life. And we were openly disparaging of them. It was like living 'Dilbert'. I mean the managers were just like the guy in the cartoon. And give him the 'Etch a Sketch'. It was just really sad. We would go to the regional forester or director of the station and say, 'this guy has no clue' and they would say 'well, that is too bad, but they are sucking it up and doing it so we are going to keep them'. . . .That is the problem. The people who were in any sort of leadership position should have known after six months that this wasn't working. All the telltale signs were there. There were overt kinds of actions that were embarrassing and the managers were like 'stay the course.'"

5.4.3 Integration as Synthesis

In order to more fully explore interviewee's views of the interrelationships between integration and their own backgrounds and viewpoints, respondents were asked to more fully consider the definition of integration and whether their project was successful or unsuccessful at achieving it. For this question, the researcher gave the interviewees a quote that described integrated research as "the process of synthesis of knowledge, approaches, and experiences into new and enriched knowledge areas." Interviewees were asked whether they thought that the project that they were involved in achieved this type of synthesis and why or why not. The variety of responses was interesting and seemed to be much more individualistic than the answers to many of the other questions. In other words, it was somewhat more difficult to pick out consistent or repeated themes from the answers given to this question.

One thing that emerged from this question is that some individuals differentiated between integration and synthesis. These individuals were often those who had been involved in FEMAT, and who seemed to equate "synthesis" with that type of research effort. They viewed the synthesis of existing ideas (as was done in FEMAT) as valuable, yielding insights that enriched knowledge and revealed relationships that had not previously been seen. One researcher expanded on this idea of synthesis to include what he termed "ex post" integration as people take the parts that are available at the end of a project and try to build a model. However, many of these same interviewees saw integrated research as organizing a group of researchers to actually test hypotheses and do original research within an analytical framework. Synthesis was seen as much less comprehensive and less expensive, but also much less likely to result in an analytical framework that could be applied to problems.

"There is integrated scientific research and there is synthesis of existing ideas. In the latter you take all the pieces and put them together, and it does enrich your understanding when you see relationships that you didn't see before. With integrated research, you are actually organizing a collection of people to do work testing hypotheses, so this can also have an element of synthesis. Up until now I really don't think that we have gotten to the point where we are framing integrative hypotheses."

Many of the people who did equate synthesis with integration responded to the interviewer's quote by saying that they did not feel their project achieved the definition described. However, it is worth noting that those who felt their projects achieved synthesis were much more likely to be administrators than scientists, along the lines of the conclusions in the section on the definition of integration. Some of those involved in earlier projects felt there was just not enough of an understanding of synthesis and integration at that time for it to have really been possible. Another factor cited from earlier studies was the lack of basic knowledge about how systems worked, which made real synthesis very difficult.

"Synthesis to me is bringing a bunch of little pieces together, whereas integration involves trying to fit pieces together in an ongoing manner. Synthesis is a retrospective subset of integration while knowledge that comes from integrated work comes in a more incremental fashion—as people talk about the different components of the system it enriches your view of how it all fits together. In some of the larger assessments it seems like sometimes they have too many bits to fit them all together. Sometimes it seems like they should try to have a broader overview instead of so many small pieces, and sometimes they seem to get too broad until what they are saying is essentially meaningless."

Synthesis was also seen as a worthy goal but one difficult to achieve, and several interviewees felt that it might be better to simply focus on problems at a more practical level. One interviewee said that his projects aim more to rise above the details of individual projects to get an idea of the big picture instead of toward synthesis. A further goal deemed more important by several interviewees was being proactive, so that research is useful to managers before problems in ecosystems occur and lawsuits result.

Another interviewee felt that true synthesis was very rare and involved a subtle distinction between coming up with *new* knowledge and not doing so. An example he cited was individuals who were studying plant and animal distribution coming together with individuals who were studying continental drift and each confirming the other's theories and new knowledge resulting. This researcher further felt that this type of synthesis could happen in small interactive groups, but rarely at the larger group level.

One other interesting idea expressed by several individuals had to do with the timeframe necessary to determine whether a project was synthetic. In this type of response synthesis was seen as attainment of an "emergent" level of higher knowledge, and interviewees felt that it might take some time away from a project before one had enough perspective to determine whether or not this had been achieved. These individuals also felt that often it is hard to know what can be learned from these projects until they have been finished for a while and you had the perspective of history. Another related point of view stated several times was that synthesis is in the "eye of the beholder."

"A good place to start [when trying to do integrated research] is doing a problem analysis which allows you to formulate a framework, find out what the available knowledge is, and define what is known and how good of an answer there already is for the integrated question. Use that to define where you need to fill holes, and test your framework on existing information."

Finally, there were several individuals that questioned whether or not this type of synthesis is truly possible, given the ways that the educational system is currently set up. One outspoken interviewee stated that people were not being trained to think synthetically and integratively and until that happened nothing would change. This individual had begun to expose his doctoral students to many different disciplines and train them to see the larger picture in the belief that only these type of thinkers would be able to deal with the future problems of society. Another interviewee spoke of the way that individuals within scientific disciplines are socialized to think of the world in a certain way, and how this interferes with their ability to think across disciplines and be integrative. This topic will be covered more extensively in the section on barriers between disciplines.

5.5 BARRIERS TO INTEGRATED RESEARCH

This research question asks what the barriers are to integrated research and how they are viewed by project participants. One of the most interesting quotes on this subject was that *"Integration is an unnatural act."* This respondent felt that integration was not human nature, was not institutional nature, and had very little in the way of centripetal forces to hold it together against the centrifugal forces trying to pull it apart. Several respondents said that because of the degree of difficulty in doing integrated research it required individuals who really loved to do this type of work.

5.5.1 Barriers between Disciplines

Problems between disciplines were seen by all respondents as a significant barrier to integrated research. These included different languages, worldviews, values, and methodology. Language was cited often, and several interviewees talked about how difficult it is to get scientists to listen to each other: *"Everyone talks but hardly anyone is listening.*" Some individuals went even further and stated that people in one discipline often did not know what those in other disciplines are doing.

> *"There is a fundamental problem with the ways in which different disciplines deal with the world. I gave a presentation as a social scientist on barriers to ecosystem management, and I was roundly criticized by a landscape ecologist because those barriers were not spatially differentiated. He felt that if they were not spatially differentiated they were useless for this project. Well, just because barriers are the same across a whole area doesn't mean that they are useless. The dominant paradigm was GIS and a computer model, and if you couldn't fit variables into the model then it wasn't relevant."*

Another problem with language in integrated research cited by several interviewees has to do with not only language that may mean different things to different disciplines, but also the lack of language that exists for working at the interface of disciplines.

"Different disciplines and people from different countries sense different implications in the use of one term or another." For example, there are different ways to look at the term 'woody debris in streams'. Debris might mean garbage to some people. . . . But if we call it "logs in streams" well, that might have a more economic meaning and thus be interpreted differently."

"There is a problem with terminology that is not consistent across disciplines. You start working with someone and you realize, 'oh, that is what you mean by that term.' I use that term for something different."

Several respondents also believe the language barrier between disciplines is more pronounced between social scientists and biophysical scientists. Several individuals stated that biophysical scientists have a difficult time understanding what it is that social scientists do and why they use their particular methods.

"Social scientists and biophysical scientists talk past each other and because the terms they use are often the same but mean subtly different things, they often don't even realize that they are having an 'apples and oranges' conversation."

"I think that we are not very good at our use of terminology. One of the problems, for example, is that there is this whole term called 'scale', and I don't think anyone really knows what it meant and I don't think that people still know what it means. We'd say 'we'll do things at a mid-scale', but no one really knew what that meant, and no one really defined what mid scale was. And it was never really clear what type of information we should collect or what depth for 'mid-scale'; do you collect lots of information? For example, if you say that you want information on populations at 'mid-scale', then do you have one variable that describes average age, or do you have a set of variables that have age distributed across different categories? No one really knows."

Moreover, according to one individual, social scientists have not been as clear as they might be about this problem in using terms that other scientists can understand.

"Biological and physical science is more quantitative, and it is difficult for the qualitative methods of social scientists to be understood fully by those who have been trained in this way."

Another interviewee discussed how different disciplines are socialized in different ways. Researchers learn to present themselves in a "professional scientist" mode that is often more a standardized way of acting within a profession than how the individual really does their work. This professional mode of behavior transfers over to methodology:

"I think that is an institutional barrier. . . . If you are going to do interdisciplinary work with a chemist, a biochemist, a physicist, anyone who can do work in the laboratory, and you are doing something that requires that you be out in the field--that is a huge institutional barrier in that in the modes of doing science the standard is the laboratory and the experiment. And for those of us who can't meet that standard our work is always suspect, which is hugely problematic when you are trying to do interdisciplinary work."

A related issue that surfaced in almost all the interviews had to do with the differences in values and worldviews between disciplines. Several interviewees talked about the ways in which foresters, engineers, and other more hands-on professions differ from the biologists and ecologists who often attempt to work with them on integrated projects. The former professions were characterized as problem solvers who look for ways to do what needs to be done, whereas the latter were described as individuals who were interested in the complexity of systems and more likely to point out problems and what can and cannot be done.

"I call these two types of scientists 'ologists' and 'ers'. 'Ologists' like biologists and ecologists are into complexity, figuring out how complex a problem is and the nuances, and are always digging at the edges of a problem and trying to find out more about it. In the management arena 'ologists' often get a bad name because they are always telling you what you can't do. 'Ers' like foresters and engineers tend to be very 'can do' people who approach everything as a problem to be solved. 'You want a road there, I can do it for you. You want old growth, I can grow it for you.' The two groups don't mix very well because you have one group

who is busy pointing out the complexities and what you can't do while the other is doing the opposite."

Another fairly common characterization related to values had to do with the viewpoint that individuals brought into a project. Several interviewees described variations of the theme that biologists and ecologists came into projects with a focus on species or system health, whereas some social scientists came in with an attitude that it was okay if the system was breaking down or we had to lose some species as long as people were still getting value out of the system. Biological scientists were often seen as having almost an advocate role for species and ecosystems, whereas social scientists or physical scientists (such as geologists) were seen as being less caught up in this role. This type of barrier was seen as being much more problematical than language differences, in that it was much more difficult to find a way to learn to get past it in integrated projects.

An unexpected but similar issue surfaced when scientists were describing differing values for disciplinary areas: respect between disciplines. One interviewee described it as a "pecking order"; another related it to the amount of grant money that is allocated to different disciplines in different projects.

"Many academics define their worth in other academics' eyes as a function of grant money or what they perceive to be average amount of grant money. Since social science is seen as being cheaper than natural science work and natural science is seen as being cheaper than physical science work there seems to be a tendency to equate grant money with value or with inherent value of the research."

"We never even really talked about what integration was as a group on my project. I brought up the fact that I thought it was more of a process than an outcome, but who was I? I was just some social science academic from some unknown university and had very little credibility."

One scientist even went so far as to say that she sees social scientists as often having a chip on their shoulder about this sort of thing in integrated projects, and suggests that this sort of professional insecurity can result in an inability to work together. However, a biophysical scientist who was interviewed disagreed:

"Quite frankly I don't think that it is a lack of respect on the part of social scientists for biophysical scientists, I think it is the other way around . . . . I think that many biophysical scientists look down their noses at social scientists, not recognizing that the social scientist is faced with much more challenging hurdles than biophysical scientists are because they are dealing with human subjects. . . . But we are making progress in that direction--this is not true for everyone, and that is a generalization."

Another researcher described the situation a little differently, explaining that a type of "macho" attitude exists in science:

"There are people who say 'this is the way you do science, and every other way is second rate."

Several individuals cited the focus and values placed on biological and physical aspects of problems as being related to the legal and political context that environmental laws (such as the Endangered Species Act) force on agency and academic research. A Forest Service scientist said this has left the PNW research station open to charges that they "care about fish but don't care about people." Several other individuals also cited these laws as having a huge impact on which areas get priority in integrated projects, thus often determining which disciplines are most emphasized.

5.5.2 Roles in Projects

According to the literature review, different roles (i.e., scientists vs. administrators or land managers) may hinder research attempts, therefore the interviews addressed this issue. Although there was some general agreement between interviewees that differences do exist (e.g., managers and scientists tend to think differently and have different priorities), most individuals did not seem to think that these roles were a large barrier to integration. There seemed to be a general sense that these types of barriers were fairly easily overcome. For example, several interviewees pointed out that many land managers have credentials in scientific fields and therefore can speak the language of both:

"As long as the project leaders (whether managers or scientists) have sufficient science credentials to be able to speak with the scientists and the land managers and understand their worldviews then they can act as go-betweens."

Another point that came up in several of the interviews was the increasing quantity and quality of relationships that exist between scientists and managers.

"I think managers today are looking more and more to scientists for help and answers, and we see scientists becoming more and more involved in the policy arena as policymakers are depending more and more on the information developed through the policy of science. So we are seeing policymakers and the federal agencies and Congress reaching out to scientists for answers to thorny issues. And we see scientists more willing now to step forward and give their interpretations of information."

One exception to the general response on how the role of managers vs. scientists affected projects came from members of the ICBEMP. As noted above several of these interviewees felt that the project lacked good relations between managers and scientists:

"There was a huge barrier in our project between managers and scientists . . . It was pathetic . . . . It was really an artificial construct, the divisions between the two. You were working on one project but you were artificially divided. It created all these status problems, it created all this enmity between the groups . . . ."

The question about administrators vs. scientists yielded even less in the way of barriers to integrated research. Most respondents seemed to feel that although there may have been barriers between administrators and scientists within their projects, these were more often related to personality than to any sort of inherent problems connected to the roles themselves.

5.5.3 Credentials/Gender/Power

Another issue that may affect attempts at integrated research is related to power relationships between team members and leaders. These can be based on gender or credentials, and the interviews tried to probe this topic. The issue was presented to the interviewees by asking if they had encountered any barriers related to some individuals in integrated projects having more credentials than others. A further question asked respondents if these issues might be related to gender and power, since the lesser credentialed researchers might often be women (at least at this point in time in the field of science).

This issue seemed to elicit two types of answers. There were many individuals who responded that influences exist, especially when it came to gender and power issues. A typical response was that it was a problem because the field of science is still dominated by white males. The scientist who earlier had described how individuals setting up these types of projects look first to their friends qualified his statement by saying that you had to be careful when you did that so you did not just end up with people who looked and thought like you, thus perpetuating the problem.

"[Gender and power issues] are a hell of a problem. The problem is that most of the senior people on projects are men, and it is only slowly changing. It is unfortunate for the projects as well as for the people involved. In one of the projects I headed it was easy to find a number of well-qualified females, but I couldn't find an equal *number. When you have no women it is horrific, when you have one it looks like tokenism, and only when you have two or more does it start to look better. You need to be willing to look beyond your usual sets of relationships to find people."*

Several individuals involved in both FEMAT and the ICBEMP described situations in which there had been problems related to gender and power. Although no names were used, a couple of individuals mentioned that in the ICBEMP there were situations in which female scientists felt that gender bias was implicated in decisions on research assignments and authorship. An interesting comment made by a member of FEMAT involved what he termed "symbiotic" relationships between older, more established scientists and more junior women scientists. The older scientists would "pontificate" and then the younger women would turn around and get things done around these ideas, and at the same time get many of their own ideas incorporated. Although this scientist felt that there were gains on both sides of these types of professional relationships, he felt that a better model might be one in which *all* points of view were given time based on the strength of their ideas and their commitment to the task. As with the scientist who stated that more credentialed white males needed to go beyond just their friends, this scientist felt that new models that did not reinforce these types of less healthy power relationships were needed in integrated projects.

The other type of basic feedback that was received on the credential/gender/power question was also fairly prevalent, and given as often by women as by men. This response equated any sort of problems in this area more with individual personalities than with inherent deficiencies in the projects themselves. Many respondents felt generally individuals with fewer credentials were treated well on these projects, and most men and women got along and had no problems working together. Most women who responded to this question seemed to feel fairly strongly that there were few barriers related to gender within the context of these projects.

"There were a couple of women in our project who were just over the top, who were really horrible to be around. But it was simply their personalities—there were a couple of other women on the project who were looked up to and regularly consulted because they knew what was going on and were very professional."

On the subject of credentials apart from gender and power issues, there were also some fairly consistent opinions. Several respondents who had participated in an administrative or leadership capacity felt that people who have tenure tend to be better at integration, because they had been around long enough to observe various system components and be intrigued by how they fit together. Individuals who were more recently trained were seen as being more caught up in their disciplinary viewpoint and perhaps less open to study of the system as a whole. Several respondents also discussed how much the graduate students who did the project field research were respected by the scientists and how hard they worked. Although many claimed that there was the 'usual' sort of grumbling that goes on in situations where rank would be an issue, there seemed to be a strong feeling that this was no more prevalent than in any other human situation.

5.5.4 Institutional Barriers

There was almost universal agreement among the study respondents that significant institutional barriers in both academia and agencies inhibit integrated research attempts. Some of the institutional barriers cited in academia include the reward system, university structure, and professional societies and their expectations. Several academics felt that there was less value placed on work in integrated projects at the departmental level when it came time for tenure review committees to evaluate and recommend for advancement. In contrast, administrators and the university as a whole seemed to value these types of projects highly--for prestige, associated high amounts of grant money, and general worth of the information generated. Respondents felt tenure committees often were more interested in individual projects that generated published papers in disciplinary journals with single authors than papers from integrated projects with multiple authors and subjects. Thus, fully tenured scientists were viewed by many as being more able to participate in integrated projects.

"The reward system in the university is a real issue. Typically when you talk about integrated research or multidisciplinary research you are talking about multi-authored papers. Somebody has got to be first and somebody has got to be last. And in some departments authorship counts. If you are first author, that means a lot more than if you are second or third author. And in many cases, especially in these interdisciplinary studies, the second author may have had almost as much contribution as the senior author. I think we have a ways to go... in recognizing the accomplishments that can take place in a team environment. Quite frankly we're are doing more and more in team environments, and the reward system needs to recognize that."

Noteworthy, however, is that several individuals who have participated in these projects strongly felt that their participation both enhanced their careers and made their work more relevant to the important issues of the day.

"I look at that [the view that integrated work is not as rewarding] and I say 'what didn't I get done that I would have done over the last ten years?' Well, I might have written more papers in smaller audience journals, but I think it put me on a whole different track of saying we need to find some answers in some other areas. . . . And you say 'well, that wasn't good stuff' [work on the landscape level integrated projects], but I go to the international level conferences and these guys are out there in the ozone, and our guys are already grappling with the real problems and are light-years ahead in terms of relevance."

Another academic institutional barrier to integrated research cited in academia was the organizational structure of a university. Several individuals discussed how difficult it was to interact with people outside of one's own department, and how this impeded the ability to learn each other's languages and research foci, as well as the chances to do integrated work. Academics on one floor were all silviculturalists or forest social scientists, while biologists and ecologists were in an entirely different building. Scientists from various disciplines who served on FEMAT, COPE, and ICBEMP felt there was a distinct advantage to their being situated in the same physical place with the rest of the team for long periods of time, and also cited having a staff which was solely working on these projects as important to the success of integration. Most individuals interviewed felt that the highly disciplinary, structured world of academia was glacial in its ability to change in response to new types of research, and that it would be up to individuals to do different things even in the face of a structure and reward system which might not value integrated work as highly.

"Universities are organized in an institutional structure in which all the disciplines are organized in their little "rabbit warrens" and this often prevents people from being able to be integrative. Because of the way that academia is set up, you end up mainly associating with people in the same field that you are in; when you go to the department picnic it is all foresters or all hydrologists or all biologists."

Interviewees who were associated with agencies also cited institutional barriers to integrated research. One barrier discussed was the difficulty in hiring and keeping individuals who might not have a Ph.D., but whose work was very good in the sense of being "boundary spanners" within efforts at integration. These individuals typically interact with both managers and academics and help make sure that the work of each is relevant to the other, but they may not be as highly compensated or valued as those with more credentials.

Another agency-related barrier within these projects is that the different administrators from various stakeholder agencies and groups may want to be in control of projects. Administrators can be from agencies or academic institutions with specific agendas related to those positions. Stakeholder groups can include local communities, industries such as forestry, or environmentalists, all with their own viewpoint about what the proper focus and outcome of projects should be. There is often a constant balancing act in trying to keep stakeholders with different mandates satisfied, and there are also issues related to the ups and downs of each agency in terms of how much funding there is available from each for integrated projects. This barrier is related to the political nature of agency programs, which many of the interviewees also cited as a barrier to integration.

"Politics can really screw up integrated research, and part of that can be an over-emphasis on meeting management needs . . . . You need a balance--if you are just supporting management needs, then the science effort may not be supported enough . . . . If you push too hard in one direction or the other, you are going to diminish your overall effectiveness. If your science is not good enough to stand up, then it is weak in the face of attack in the political and management arena. But if you are only doing science and it is not relevant in the face of policy and management, then you are going to lose the support for your science."

BARRIERS TO INTEGRATED RESEARCH

- **Barriers Between Disciplines**
  - ✓ *Language Differences Between Disciplines*
  - ✓ *Different Worldviews*
  - ✓ *Differing Methodologies*
  - ✓ *Value Differences Between Disciplines*
  - ✓ *Lack of Language for Working at the Interface Between Disciplines*
  - ✓ *Large Gap in Understanding and Language Between Social and Biophysical Scientists*
  - ✓ *Lack of Respect Between Disciplines*

- **Roles in Projects**
  - ✓ *Lack of Good Relationships Between Agency Personnel and Scientists on Projects*
  - ✓ *Agency Personnel Might Not be as Credentialed, but Very Important to Relevance to both Agency and Academia*

- **Credentials/Gender/Power**
  - ✓ *Science Dominated by White Males, thus Limiting Input by Women and Minority Groups*
  - ✓ *Smaller Pool of Women and Minority Scientists and Researchers to Choose From*
  - ✓ *Possible Unhealthy Power Relationships when More Experienced Scientists are Men and Women are Less Credentialed*

- **Institutional Barriers**
  - ✓ *Reward System in Academia Geared More Toward Individual Research Instead of Integrated Projects*
  - ✓ *Multi-Author Research Papers From Integrated Projects Not as Highly Valued by Tenure Committees in Academia as Single Author Disciplinary Papers*
  - ✓ *Organizational Structure of Universities Which Make Interactions Between Departments Infrequent*
  - ✓ *Stakeholders in Agencies With Differing Agendas which have to be Balanced*
  - ✓ *Variable Agency Funding often Related to Political Climate*

5.6 ADDITIONAL FACTORS WHICH AFFECT INTEGRATED RESEARCH

The final research question to be answered involved an examination of the substantive factors that affect the success or failure of integrated research projects. Some of these cited in the literature include context and scale of a project, funding, leadership, and team composition.

5.6.1 Context and Scale

Despite its prevalence as a factor listed in the literature review, many of the individuals interviewed were not particularly interested in talking a great deal about the context of their projects or how it affected the integration of ideas. Some of the definitions of context that were discussed included those related to political context and the crisis mode of problem solving (that emerged in FEMAT and to some degree in the ICBEMP); barriers related to how scientists work together and the interactions between agencies and academia; and the contradictory values of society for natural resources. Although many of the interviewees cited these various contexts as influencing the success of integrated projects, they also stated that many sorts of projects in natural resources face these issues today, and the effect on integrated projects was not especially unique.

Scale was an issue that many interviewees were more forthcoming about, however. One common view was that the spatial scale agreed upon at the beginning of the project determines which processes and disciplines, and even individuals, would be included in a project.

Several interviewees talked about how the evolving processes of satellite imagery and spatial information are starting to be included in integrated projects, and how much remains to be done to understand how to fit together various scales of information from different disciplines using this technology. Individuals also mentioned the spatial "mismatch" that often occurs between data in different disciplines; for example the difference between economic data collected at the community level and biophysical data collected at the watershed level. It was also noted that some individuals questioned whether the current emphasis on use of this type of information might make certain types of integration less possible, both because of the cost and the difficulty of putting particular types of information (for example, some types of social science data) into this format.

"The scale that you choose up-front—whether you know it or not—has a good many implications for what types of disciplines and information can participate . . . For example, at a big scale like the Coast range—how much detail can we really bring in as far as riparian areas or roads or some of the fine scales of stand conditions? It's hard to anticipate that. We don't have a good sense of how to do spatial information. We've got one type of information—satellite imagery—that potentially gives you millions of pixels such that each pixel is 25 meters across, and then we try to mesh that with an ecological model of forest growth or with a social science model over a community or at the county level, and there is a real mismatch there. So there are tradeoffs and limitations from choosing what spatial scale you operate in. That's just one example of where decisions made up front can limit integration."

Some respondents also discussed individuals who were better at thinking at larger scales as opposed to those who were not. Different people from different disciplines were seen as being more comfortable working at different scales, and this was a factor that had to be considered when recruiting individuals for these projects. Some types of researchers were also seen as better able to abstract to both larger spatial scales and longer temporal scales.

Scale was also seen as determining the types of relationships and questions that researchers might consider. When the scale is smaller a project uses different types of information at a finer scale, whereas a larger project such as the ICBEMP was seen as having to use much more generalized broad-scale information. Many interviewees agreed that when the scale gets too big it is difficult to be integrative, and cited the ICBEMP as an example. When this is the case, the money and the work have to be more focused on the key problems and locations, because it is not possible to be doing something everywhere. Some believed that when the scale is bigger it is more important to pay attention to research design, and to make sure that the research methods accurately incorporate and represent the area being examined, so that conclusions can be generalized to the larger region.

One other aspect of scale discussed by several interviewees was temporal scale. There seemed to be a consensus of feeling that most of these studies require long-term research, but they run straight into a funding system that does not recognize this need. Funding for many projects is yearly, or at the most comes in six-year increments; however, data requirements for longitudinal research may run into decades or even centuries. For this reason, many interviewees cited reform of the funding system as one vital element to addressing the issues of scale encountered in these projects.

5.6.2 Funding

Most respondents felt that funding source, process, and availability will have substantive effects on whether and how integrated research is done. Some of this is discussed above, so the sections below will focus on how funding affects projects of different types.

The funding issues on the bigger projects such as FEMAT, COPE, and the ICBEMP were somewhat different than those associated with the other two case studies. Interviewees involved in the former projects did not generally have a great deal of experience with the funding because it was handled at the administrative level as opposed to the grant process. Several interviewees who had been administrators discussed how the budgeting earmarks associated with the projects affected the attitudes of the team members. Mandates from Washington, D.C. which required addressing specific research issues caused some hard feelings from some of the scientists if their particular field was not as well funded as others.

A related issue that surfaced in the interviews was the way funding was allocated within some of the larger scale projects. Social scientists especially seemed to feel that the funding issue affecting them most was the add-on nature of the social component in these types of projects.

"I think that funding is more a barrier on the social science side than on the biophysical science side. Doing [these types of projects] is very costly and my experience has been that doing the social science is more of an afterthought. . . . Social scientists not only have to go through the Human Subjects board but they also have to get Office of Management and Budget approval, and it can take months. Biologists don't have to do that, and if a project needs the social information quickly, then they often bypass the social scientists and find some other quicker way to get the data that may not be the best."

An issue that came up in several of the projects was how limits on the amounts of money available and the need to continuously look for new funding can negatively affect a researcher's ability to work integratively. Interestingly, several respondents stated they had been involved in projects in which there had been little or no funding and had found that the camaraderie, level of collaboration, and commitment was higher solely because the individuals involved were there because of their interest in being part of the project. Once these projects grew and obtained more funding, however, there was a need for someone to continuously look around for money.

"In these types of [integrated] projects I would always want either unlimited money or no money, because then you don't always have to be worrying about the budget. When you have a limited amount of money there is always a battle over the budget, and that creates friction and takes energy . . . and is debilitating to the project."

The ability of a project to sell itself was also cited by numerous individuals who had been involved in some smaller projects. The degree to which the project is relevant to policy and management issues of the day was seen as one of the principle reasons that some projects got funding while other did not, and buy-in from the funding agency or institution was cited as extremely important to the ability of a project to be integrative.

"Sometimes I think that we set up integrated projects because we don't know what to do, just that something needs to be done. And then getting the money is largely a question of how pressing a problem is. If you have a clear and present danger like the A-bomb, then the money is a lot easier to get. Another factor that has a lot to do with how successful you are has to do with the amount of buy-in that your benefactor or funder has in the project. But on the other hand, if there is too much buy-in, then they try to control the project."

"I think that we were lucky because [our project] would not have existed if it hadn't been for this big controversy in the Pacific Northwest that triggered both interest in the work and some funding mechanisms. . . . It would be difficult to fund this type of a project unless there was a crisis. . . and we were opportunistic in that we took advantage of these crises. If you are ready to strike, then you can get funding . . . It is kind of like a 'window of opportunity' thing."

A final funding issue that surfaced regarded the flexibility that comes with a large enough budget. One interviewee recommended that integrated projects should have a portion of the budget reserved for contingencies, and have the flexibility to respond to unanticipated circumstances or findings. Typically, this is not done because proposed budgets have to specify exactly how the money is to be spent. However, this interviewee's experience was that in order to mitigate or compensate for problems in the course of a project, it is necessary to have the financial resources to respond to unexpected difficulties.

In contrast to these barriers, most of the interviewees felt that funding for interdisciplinary, integrated work is increasing. Several respondents cited the recent National Science Foundation Request for Proposal for research on biocomplexity as an example of this. This RFP promotes a "systems level approach for expanding scientific understanding of large scale environmental issues" and encourages the integration of biophysical and social scientists (NSF, 1999). Interviewees also seemed to feel that integrated research would be required more and more in the future, as policy issues related to natural resources become increasingly complex and scientists become extensively involved in natural resource controversies.

"I think integrated research is the wave of the future. And I think that it is going to become more and more highly integrated. I think that you are going to see more and more collaboration between the biophysical scientists and the social scientists."

"I think it is exciting times, and I do think that the blending and integration . . . is not going to be a short term thing. If anything, these assessments have brought tremendous amounts of interest on the role of scientists as advocates. And I think that there is going to be some misuse of that, but I think that by and large that debate is healthy. . . . Many scientists went into these things to make a difference and learn something about the world that would be useful. I think that that is a motive that is real with most people. I think that [integrated projects] will help scientists become more and more relevant to the policy debates."

However, there were still individuals who were somewhat pessimistic about the possibilities for integrated work in the future, given the culture of science that exists today.

"Science itself is not interdisciplinary any longer, although it started out as more interdisciplinary and holistic than it is now. Science as an institution is a basically fragmented, functionalist, positivistic kind of approach where along the line we have decided that the only way that we can figure things out is by breaking it up into its smallest pieces. And even though some of the funding agencies are saying that they want interdisciplinary [integrated] work, you still aren't seeing a lot of money being put into those projects."

Citing previous projects, several other scientists stated that integrated research was not necessarily a new phenomenon.

"I do think that there will be more integrated research in the future but I also think that it is mistake to say that we haven't been doing it in the past. I think it is a natural progression of attempting to answer increasingly more complex problems. The complexity is not because of the depth disciplinarity, the complexity is because of the breadth disciplinarity."

"I think that you can do interdisciplinary, integrated research at a smaller, less expensive scale than these multi-million dollar projects. Integrated projects have a huge risk of failure just in themselves, and, when you do it at such a large scale, the risk of failure is humongous. We could think about ways to approach it at a smaller scale even though we are trying to think holistically."

5.6.3 Time Allotment

When asked about the issue of time allotment and how it had affected their ability to be integrative, two types of answers emerged from the interviews. One usually involved scientists discussing how much more time it took to do integrative work than disciplinary work. Points made included: time to talk and learn each others' languages; time spent figuring out how the methodologies, scales, and contexts of the various disciplines could fit together; and time spent brainstorming and agreeing upon questions that could be answered integratively.

"The time for these projects is usually five to ten times what you originally think. These things are very slow to develop and can be very frustrating. You can talk to anyone who has worked on any of these projects, and they will tell you that they never finished on time or got done what they had hoped to do. So you need a lot of patience, but you also need an impatience to try and bring the thing together because you could keep on going forever. There is always some new piece of information or some discipline that wasn't there before or some new GIS toy or something that you can add to make it better."

As mentioned previously, many interviewees also talked about how funding is directly tied to research duration--one individual stated that "*You have to buy the time*" in integrated projects.

The other form of discussion about time had to do with how much time is allotted for the project itself and how this affects the integration. Many interviewees agreed with the viewpoint encountered in the literature that it is possible to have both too much and too little time for these types of projects. Interviewees seemed to feel that projects such as FEMAT perhaps had too little time, whereas projects such as the ICBEMP had too much time. The following quotes were typical:

"You do need some deadlines, you absolutely do. But you also need a fair amount of time especially if it is a research project. If it is something like FEMAT and you are trying to synthesize existing knowledge, then it can be done in a much shorter period of time. But research on an issue can go on for many years as long as you produce some products from it. Obviously you can't just go ten years and then say 'here's our paper.'"

"In looking at FEMAT and the Interior Columbia basin project, I would first say that we did not have enough time on FEMAT—we really only had 60 days. . . . The ICBEMP was almost exactly the opposite. They had almost no time schedule and tried to incorporate everyone, I think very ineptly. One of the things that saps people's morale is that they feel that there is no end. I would look for some sort of middle ground, with some checkpoints in between and with a better sense of the problem."

Another interesting quote about the ICBEMP concerned the way that the time boundaries were structured in that project:

"There was a time issue in the ICBEMP. . . The first charter said that the time allotment was six months so we were working under that deadline. . . . And then the deadline was moved back several months. . . and then it was moved back again and again. So what happened was that we were always under a time constraint. We were always just a few months away from a deadline which kept being moved back. . . . If we had known from the beginning [the amount of time that we would ultimately have] we would have addressed and structured our research in very different ways."

Finally, this scientist as well as several of the other social scientists interviewed felt there was also a difference that needed to be recognized in terms of the temporal dimension of social versus biophysical research. One social scientist remembered a conversation in which he was asked what his projection was for some sort of human variable in the next three hundred years. He says that he laughed and then said "the next three hundred years. . . I can't even tell you what is going to happen in the next *thirty* years."

5.6.4 Leadership

The literature review noted how important leadership is to the success of integrated projects, and virtually every interviewee agreed and added their sentiments about importance of having good leadership. Many also listed the leadership qualities that they felt were required for these projects.

> *"Leadership is everything in integrated projects because they are not rule based, i.e., there are generally not definite rules about how to go about it, so you need leadership to help you forge the way and keep going. Good leadership also helps keep people willing to come to work and work together. . . . The most important thing in this type of project is leadership."*

> *"Leadership is very important and the leader in projects that have policy implications needs to be able to function in a political arena and be able to shield the team members from political pressure if necessary."*

> *"Leadership is critical. You need someone who is open, who can bring people together, and who can incorporate new ideas so that people get more out of it than working separately. . . .You have to have someone who is able to find a way to make the whole more than the sum of the parts and who is able to keep things moving through toward a sense of the final destination."*

"People go with what they know, so if you put an ecologist in charge, then the project will have a strong ecological emphasis; and if you put a manager in charge, you will have a strong management emphasis. So one of the qualities of a good leader is being able to push yourself out of your own box to broaden participation as much as possible, keeping an eye on whether or not it becomes too unwieldy."

Other qualities that interviewees felt were important in a leader for integrated projects were: 1) enough ruthlessness to cut funding to individuals who did not do the required integrated work; 2) someone who is not autocratic and who is tolerant and respectful of different personalities and different disciplines; 3) being able to articulate the common goals for the project and accurately describe the project; and 4) the ability to be the spokesperson for the group and to be a champion for the project. Several scientists mentioned that the leader had to have a view of the whole project, but must also take the time to understand the issues facing the members of his/her team.

"I am very bitter about the leadership on our project. One of the things I am bitter about is that they never, ever asked me if I had a family. Not one of them ever expressed a personal interest in me. I commuted back and forth to the project because I couldn't move my family and not once did the leadership say 'Gosh, that must be difficult on you and your family.' I mean, they didn't even know that I had a family, and I think that that really, really hurt my attitude. When I got over there, I would work 70 hours a week and not one person ever said 'thanks' out of the leadership team."

"I don't think of myself as a leader at all on my project. I think of myself as more of a mom. I answer a lot of questions and wipe a lot of noses. And then there is also this used car salesman aspect to it. I take the product that is coming out of the projects, and I spin them into larger issues, and I make them glossy. I go give presentations about the whole program as well as about components within it . . . . I don't say to individuals 'you must do this or you can't do that.' I feel like people have to make their own choices about what they want to do, and then the group has to make a decision about each person's efforts and whether that effort is going to

work into the whole program or not. I think the word facilitator is probably better."

5.6.5 Team Composition

Composition of the team can have an effect on the degree of success of the project and the integration achieved. Although the literature supported this as an important factor, it was surprising how strongly the interviewees felt this to be true. All the interviewees believed that the individual personalities of the team members had a great deal to do with whether or not they were able to work together in an integrative way. The following quote was typical:

"Personality counts for a lot. You have to have personalities that can work together. . . . [In our project] we took the people that fit the position well. There was some discussion about teams, but with a lot of these things you don't know until you get the people together whether they will get along. . . . We did learn from [our project] that you have to turn over more stones in the search process. Most searches today now look at personalities and ask lots of questions. You better believe that personality plays a big role."

A couple of interviewees discussed how difficult it can be to participate in interdisciplinary, integrated projects, and suggested this factor should be brought out when an individual is thinking of becoming a member of this type of team:

"It is really much harder to do interdisciplinary integrated projects. When you are doing interdisciplinary work, it is like being out on a precipice because there is no precedent for what you are doing. I like the disciplinary projects I work on. I feel accomplished when I work on them, I feel professionally competent. But I don't feel exhilarated in the same way as I do when I am working on an interdisciplinary project that is going well. This may be my own bias, but I really do like thinking about things in the whole, rather than the part. I actually often go back to doing the disciplinary work because it is relaxing, because it is easier to do. So if I need a respite from the interdisciplinary battles, I will do something more disciplinary bound."

This learning process was repeatedly mentioned in the interviews as a key element that has changed from the earlier projects to the later ones. On some projects there were problems among team members, and this led many of them to reevaluate how they went about choosing who should participate.

"It is absolutely critical to have good key people. We had one person who ended up almost single-handedly destroying the whole project. And then we got someone who almost single-handedly brought the project back up. It became obvious how important one person is in integrated projects . . . . This was not considered when they put the team of scientists together. They wrote job descriptions and went after people with disciplinary qualifications and didn't give a lot of consideration to how well they could work together. . . . We ended up finding out that the ability to work with others was a lot more important than publications."

Several of the interview respondents also noted personal qualities that they felt were crucial to working as a team on integrated projects, as well as others that could interfere with achieving integration.

"The bridging work necessary to bring scientists from different disciplines together depends on getting the right group of people together who are willing to spend the time to interact with each other and who can do that in a positive and non-competitive way. You also need people who are interested in understanding the system and not just in their own little disciplinary niches. . . . From all of these projects we have learned that the more [integrated work] you do the better you are at it, and the more enthusiastic people become about participating in these types of projects."

"Self aggrandizement is the name of the game in academia . . . and there are individuals who are very good at putting their names up there in lights, and they tend to be very successful. And those people who are good team players and make significant contributions, they have a little bit more difficult time. This is changing, however, and a lot of that has to do with faculty retiring. . . . It's kind of the old school and the new school. That doesn't reflect that one scientist is more humanistic than another or that one scientist is better than another; it reflects the changing culture of science and what we have in front of us to do. The problems of today have a different dimension than twenty or thirty years ago. . . ."

In the next section, recommendations received from the interviewees as to how to best structure integrated projects in the future will be discussed.

FACTORS AFFECTING INTEGRATED RESEARCH

- **Context and Scale**
  - ✓ *Projects Often Occur in Atmosphere of Crisis*
  - ✓ *Society has Contradictory Values for Natural Resources which Affects Project Structure and Desired Outcomes*
  - ✓ *Political Climate can Affect Projects*
  - ✓ *Scale Decisions at Beginning of Project Determine Disciplines Included and Type of Research Done*
  - ✓ *Evolving Technology (Especially GIS and Satellite Imagery) Impacts how Research is Done and how Elements/Disciplines Fit Data Together*
  - ✓ *Spatial Mismatch can Occur Between Different Disciplines and Types of Data*
  - ✓ *Cost and Difficulty of Putting some Types of Data into Spatial Formats*
  - ✓ *Differing Abilities of Researchers to Think at Different Spatial and Temporal Scales*
  - ✓ *More Difficult to Make Large-Scale Projects Integrative and Account for Important Problems Because more Generalized Information Used*

- **Funding**
  - ✓ *Earmarked Funds due to Political Mandates can Determine Where Funds are Spent*
  - ✓ *Social Component can be an Add-On or Afterthought if Not Initially Funded*
  - ✓ *Continuous Process of Looking for Funds Uses Administrative Time*
  - ✓ *Limited Funds can Cause Friction and Consume Project Energy*
  - ✓ *Projects Need to be Relevant to Get Funding*
  - ✓ *Projects Should Reserve Funds for Contingencies*

FACTORS AFFECTING INTEGRATED RESEARCH (CONT.)

- **Time Allotment**
  - ✓ *Integrative Work Takes More Time than Disciplinary Work Given the Time Necessary for Learning Language, Methods of Other Disciplines*
  - ✓ *Have To Guard Against Either Too Little or Too Much Time Allotted for Projects*
  - ✓ *Temporal Differences in Social v. Biophysical Research Need to be Recognized*

- **Leadership**
  - ✓ *Leadership is Very Important Because Integrated Projects are Not Rule-Based*
  - ✓ *Leaders have to be Able to Function in Political Arena*
  - ✓ *Leaders have to be Open, Be able to Bring Diverse Researchers Together, and Incorporate New Ideas*
  - ✓ *Leaders Have to be able to Articulate the Common Goals for Project and be Spokesperson for the Group*
  - ✓ *Leaders Have to be Respectful and Tolerant of Different Personalities and Disciplines*

- **Team Composition**
  - ✓ *Individual Team Member Personalities can Make or Break an Integrated Project*
  - ✓ *Personalities have to be Able to Work Together and not be Prima Donnas*
  - ✓ *Much More Difficult to Work in Integrated Projects than Disciplinary Projects*
  - ✓ *Need to Examine Personalities When Hiring for Integrated Projects, Perhaps Even More than Credentials*
  - ✓ *Team Members Need to be Interested in the System, and Not Just Their own Disciplinary Niches and Self-Aggrandizement*
  - ✓ *Team Members Need to be Able to Interact with Each Other in a Positive and Non-Competitive Way*

CHAPTER 6

RECOMMENDATIONS

6.1 INTRODUCTION

In this section, recommendations from interviewees on how to plan and structure future integrated projects are described. Suggestions for future research on integration is also considered, as is the future of integrated research itself.

6.2 PLANNING RECOMMENDATIONS

Many of the respondents to this interview process discussed the necessity of careful planning for integrated projects. Often the first recommendations for future projects had to do with beginning slowly, and with taking the human dimension into account:

"You need to stop for a minute and look around at the literature and the experience others have in doing integrated research. Talk with people and read and find out what works and what doesn't work. Deal with the human dimension from the very beginning."

"You have to look for a certain type of people. The best thing is to get the very best people and enable them. To say, 'this is what needs to be done and I trust you to do it. If you need resources I am going to trust your judgment about resources, whether it be people or money, and you can operate outside the normal organizational processes and rules and so forth. You can do what needs to be done to see if you can solve this. If you have to think in imaginative and creative ways to do this, more power to you.' Some of the private sector groups that have done this do it this way. They say 'look folks, go away, here is the accountant's number and here are the lines of authority and see what you can come up with.'"

Of special concern also seemed to be the emphasis placed on getting the participants together before the project begins to learn about integration, to discover each other's languages or develop a language of their own, and to formulate integrated questions:

"You need to look around and say who are the type of people I have heard about, who can think integratively and who have demonstrated an appreciation for different views. A demonstrated disposition to be open minded, and there are clearly people who don't do that well. We might at times want to go to those people even though they would not be at the core of the project, when we have a very narrow, defined part of the problem. You also have to have some way of determining if people that we thought could work integratively really can't. Some way of saying 'OK, we made a mistake here, but if she's not right then who is.'"

"First you need to start with a forum for mutual learning, some place to sit down and talk to each other. I listen to you and say to myself, 'Boy, that's a weird way of looking at the world' and think after a while, 'well, you know that she is right.' And you do the same thing to me so that eventually we come around to saying 'now based on what we have learned from each other, what is our perception of the problem and what do we think we need to do to solve it?' So you have to start with mutual learning. The early days of dialogue can be very hard."

Forming integrative questions received a great deal of attention from participants. Many of them stressed that in today's natural resource environment it is important to get policy makers and citizens on board, as well as scientists and agency personnel to help define questions.

"We are realizing more and more that until we are smart enough to ask the integrated questions, it is very, very difficult to do integrated research. That is why it is hazardous to do integration at all—you might end up with a bunch of pieces that don't even fit together after all your time and effort."

"One of the best things about COPE was the support we received from the stakeholders. We worked really hard to involve them in determining what the important questions were that they needed answered in dealing with the coastal forests. This was important for our continued federal funding because when it came

time to refinance we had local people who had put money in putting pressure at the federal level to continue funding."

"In COPE there was collaboration not just between scientists but between a variety of public and private interests. We need to think about the collaboration types that can provide support in one way or another. However, the thing that was missing was the environmentalists."

Some interviewees discussed how difficult it sometimes is for scientists and land managers to treat local community members with respect, but stressed that if local buy-in to the project is important, then the necessity for this type of respect should be emphasized to all project participants.

"This is an oversimplification, but for example, think about wildlife biologists. They might be thinking, 'wait a minute, I went to school for six years and I have a Master's Degree. You're telling me I have to sit here and listen to some local outfitter talk about the elk population?' One of the things about integration is that there are some fascinating power issues going on."

"I would recommend being much more inclusive in the process of framing the question. And that includes scientists, managers, and the members of the public who are going to be affected by the decision. And I would spend a long time on that—that is the most important thing in any integrated process in my opinion, and from it everything else flows. This is difficult to do when your project is on a very broad scale, but is much more possible on a smaller scale."

"Having the public involved is crucial. I feel that a dialogue is needed with the public. What we did on my project is have monthly briefings on what we were doing, and very rarely did we ask the public to think about what we were doing or give us their feedback. I think that you need to have a dialogue, not an informational kind of thing. An emphasis on learning and interaction."

6.3. ORGANIZATIONAL STRUCTURE OF PROJECTS

Regarding structure, one of the most frequently mentioned aspects was consideration given to the scientists themselves. Most individuals felt that with the institutional barriers to integrated research in both academia and natural resource agencies there had to be good incentives for both scientists and agency personnel to participate.

"You have to look at the incentives for people, both inside and outside. Paying scientists by the hour is one approach to increasing participation in integrated projects, because it gives them an incentive to sit through those long, boring meetings. When you get a bunch of scientists together, it is like a meeting of the world's great religions—no one can understand each other and after a while you just give up trying. And that is tough to overcome. So either have to have a strong desire to do it or you have to be paid to do it."

"We need to structure our reward systems to reward team work, not individual work, and that is central. Money and being able to answer an interesting question, public exposure, working with funding on bigger questions they are interested in, and future work offers or promotions are incentives. The science questions of integration are small compared to the institutional barriers to integrated research because we have a better idea of how to solve those problems."

"Long term money is important for both the level of integration and to motivate the scientists. It is also important to have buy in from all the major players so that funding is not cut part way through the project."

How projects were structured in terms of time was also frequently addressed by respondents. Although many participants felt there had to be some better ways to temporally structure projects, suggestions for solutions were often sketchy:

"When we started out we had a set amount of time in which to get our part of the project done. But then the deadline was moved several months. And then it was moved back again, and then again. So what happened was that we were always under a time constraint, always just a few months away from a deadline. If we had known at the beginning exactly how much time we would have had we would have done our research a very different way than we did when we thought we were a few months away from the deadline. So even though it may seem that we had a lot of time, our time frames were actually really short. If someone says that you have a few months to do this research then you adopt one strategy, if you are given a year or two then you do things totally differently."

"I am a tremendous fan of long term projects. I think that short-term projects, even several year projects, when you are trying to do something large and complicated are a waste of money. Because you can't possibly get anywhere in a short space of time. And here's a soapbox. Kind of a related point is that in many, many related areas of academic research it is very, very difficult to get money for monitoring. 'Monitoring' is this bad word. And yet, all of the things that we are now finding out about how the physical environment affects the biological environment and how humans are affecting the biological environment come from long term monitoring data sets. They don't come from short-term experimental data sets. And so there is a tremendous, tremendous conundrum there. So if you have a short-term project, whether multidisciplinary or not, it has to respond to the short-term fads within those disciplines. You have to go test some cool theory that everyone is talking about because that is the only way you are going to get anything out of the project. And doing that sort of thing might be relevant for academia, but it certainly isn't relevant for the real world. So that is why I feel that longer is better."

"Having things be open ended in time and money without specific goals I think also is not a good thing. I think that large projects should be done in chunks with at least a basic conceptual work plan so that the ensuing projects are based on completion of work from the interval before. Knowing that things are going to evolve as people work on them. So you can't be prescient and know everything that is going to happen and plan the future. But you can at least make some goal statements and those things need to be done."

The interactions between leadership and some of the other facets of projects was also discussed by interviewees, with many seeming to feel that the ability of leaders to be effective was often constrained by variables like time limitations, personalities, and administrative structure of projects. For example, leaders in projects might not be able to structure projects as they wished or involve researchers in the most productive ways because there was not enough time, or money, or because individuals involved were not willing to commit to this degree of involvement. Recommendations included qualities in leaders that might mitigate against these problems, as well as changes to the other constraining factors.

"I think that you really need to find people who want to work together. I also think that you need a leader who can adapt leadership styles to different individuals. For example, I am pretty established in my career and so don't need a lot of guidance from my department head. But younger people do, and I think in a project like this you need someone who understands that and can motivate people and make them want to do well. A good leader of one of these projects needs to be able to sit down after the problem if framed and have enough knowledge to write down the conclusions at the beginning of the project."

"The leader of our project was faced with some real problems in that the members of the teams were not directly accountable to him, they were accountable to their team supervisor. So he had a difficult time when he tried to get do something because they could always say 'well, my team leader wants me to do this' and that is a higher priority."

"The leader on our project did not have a very good vision of what I would call 'integration'. His vision was 'everyone go off and do their own thing and then get back together at the end of the project and integrate the stuff'. So what happened was that you had people selecting data on whatever they thought was interesting and what they thought the problem was. And every one of us had a different definition of what the problem was. There wasn't any common framing of the problem . . . . The data was collected at different scales, for different purposes, and when we came back together again to bring it together it didn't work out very well. He just didn't get people together early enough on a common vision of integration."

"I would make sure that I set some boundaries on a project. Some very discrete checkpoints. And before setting time frames make sure that we get a better sense of the problem. We would get together and set them up and they would be OUR deadlines for whatever it is. I would also have an ongoing negotiation process, not only about deadlines that we might not think we could meet once we got into a project, but also about the issue of the problem. Perhaps we might need to start compartmentalizing or prioritizing the nature of the problem. Perhaps there would be some hierarchies, or some important things that we just can't get to right now, or we can't get to this until we do that."

6.4 PHYSICAL STRUCTURE OF PROJECTS

Most of the participants in the interview process felt that how the project was physically structured in terms of work location was an important variable to the success of projects. Members of both COPE and ICBEMP felt that it was a positive factor to be in the same location with the rest of their team; alternatively, when members were isolated from other colleagues this had a negative influence on both the human and integrative aspects of the projects. The members of FEMAT also generally felt that the very physical proximity of the teams to each other had a positive effect on the degree of integrated, new knowledge that the project achieved. Both CLAMS and CFER scientists are generally located in the same place, and the project managers and planners have deliberately structured the projects this way.

"I would recommend having everyone in one physical place. I think that is a serious drawback of the project I am working on now. And though I understand completely why there needs to be people spread out across institutions, it makes it extremely difficult . . . . For instance, one of our scientists is all by herself. And if she wants to interact with the other project participants she has to get in her car or get on a plane or call them on the phone. She doesn't have the ability to walk down the hall and talk to other people and I think that that is a serious drawback. So I think that you need to get people all together in a single place, at least for a serious chunk of time. If you have enough money, do it as part of an institute where you have a bunch of rotating positions and stays where people can come in and work basically full time on a project. And you are housing the both the social and biophysical people together in the same building."

The difficulties of attempting to be integrative at the end of the project as opposed to starting with integrative questions was also mentioned by a number of interviewees. Several interviewees discussed how having an analytical framework supplements integration if it is in place at the beginning of a project.

"If there is an analytical model and structure that seems to greatly facilitate the integration because it greatly influences the precision of what the interface looks like between the various models. I have found that when you have some sort of analytical system where you can see which variables influence each

other (no matter how loosely structured or how loose the arrow might be from one box to the other), then you end up with a far greater likelihood that you have asked and answered some integrated questions."

6.5 PROCESSES TO OVERCOME BARRIERS

Many different suggestions were made by the interviewees for overcoming the barriers to integrated research. One idea involved the language barrier between disciplines in language; it was suggested that people who are going to do integrated research should read each other's papers and then discuss them to reach a common understanding of basic concepts.

Another suggestion was to make sure that one discipline was not totally in control of developing the question and problem framework for the project.

"If the basic structural model is developed only by one discipline then that is going to be a major barrier because variables from the other disciplines may or may not fit into to the model."

"If you bring in some disciplines after the initial problem framing, that suggests a lack of fundamental respect for what that discipline can bring to the table. And I have seen this occur on other projects. I worked on one project where they defined the structure and then they brought the social scientists in. Consequently there wasn't a very good role for the social scientists because they had already defined the structure of the project so the social scientists could not exploit and use their own area of expertise because of the way that the problem was defined and the scope of the research project had been defined by the biologists."

"One way to overcome barriers is to bring ALL the disciplines in together in the beginning and have them participate in the framing of the problem and then they understand how their particular discipline can contribute to that. That is essential, and that may take a while since it is the most difficult part of the process. This can overcome many of the terminology problems as people learn each other's language and it may also create a sense of ownership in the modeling that has to be done, and the contribution of each group."

Other scientists suggested that individuals who will be working together on an integrated project should go out together on the ground and see how each describes what they see. An example given was one project leader who took his interdisciplinary team into the mountains and had them describe to each other what corridors they saw. Biologists talked to each other about wildlife dispersal corridors, sociologists talked about how people were recreating on this side of the mountain and living on or commuting to the other side, and economists talked about how roads were corridors whereby goods were carried from a production center to a consumption center. Through doing this, the scientists were better able to understand each other's languages and worldviews.

> *"By describing what we saw we were able to better understand the different terminologies, worldviews, and thus how things fit together. This step also reveals the different normative components—different descriptive components have imbedded within them different normative components—not just about how the world is, but what the world* should *be like. I think that being able to have this discussion is valuable because many disciplines don't realize that they have a normative component. For example, ecologists don't realize that they have a normative component—that imbedded within their way of describing the world is the normative concept that what they are describing is "good" and that therefore we should try to achieve it. These types of discussions may also reveal some of the master metaphors within disciplines—the foundation reasons why the components don't fit together—and these may have some normative dimensions imbedded within them."*

Most interviewees said that allowing the team time to work through a communication process is the factor most necessary in overcoming these barriers to integrated projects. Talking to each other at meetings was one of the ways that projects had attempted to overcome language barriers, and ability to endure long, boring meeting was cited several times as a necessary skill for working on integrated projects. One interviewee who had lead integrated projects also suggested that integrated exercises be done at small meetings. She had her team members do exercises which exposed them to each other's languages, and also had a lunch time seminar series in which an individual from one discipline in the project answered questions about the type of work they were doing and their particular research design. Empowering small groups to come up with a language that they understood and then allowing them to solve a problem was another suggestion made several times in the interviews.

"Figure out as many ways as you can, more towards the informal than the formal, of providing opportunities for integration. And that is everything from seminar kinds of things, all the way down to eating meals together."

Several interviewees discussed methods for overcoming the institutional barriers to integration, especially those related to the reward system. One scientist who heads up an integrated project is structuring his program to help provide opportunities for both individual work and publications, as well as for the overall integrated work. Each researcher in the project is assigned a post-doc or research assistant, who is responsible for the day-to-day work; thus enabling the senior scientist to keep up on the project work but still work on other things. Under this arrangement, the research assistant can generate specific project information as well as assist the scientist with details needed for publication purposes. The more general information is then integrated with information from other disciplines for the project as a whole, while the more disciplinary information is utilized by the scientist.

"My point of view is that you have to make the scientists happy or they are not gong to play. And they are happiest when they feel that they can do their own thing and *feel that they can make a contribution to the policy model or the integrated model--which may not require as complicated a level of analysis [as the disciplinary work]."*

Another individual described a similar type of project structure in which there were various modules within the project, but responsibility for the entire project was the job of only two lead scientists. Therefore, the scientists were able to get out publications on their modules even if the project as a whole failed. However, if the project as a whole succeeded then each individual scientist would have a vehicle for their module that they would not have had otherwise. This individual also felt that in using this lead scientist format, it was important to have sufficient institutional continuity in order for integrated projects to succeed. There has to be consistency in question definition, consistency of funding, consistency of reward system, and a method to keep the project on track.

"You have to get the resources, you have to get the people, you have to get the external support vehicle to be able to maintain all of that, you have to keep the people on the integrated resource project and not have them dragged off somewhere else. You have to be able to deal with staff turnover so that if one person leaves it is not like a flat tire on a car. . . . There is more risk of failure with an integrated project because the failure of one component can make the whole project fail. You have to design the project so that it is resilient enough to deal with the inevitable failures of the individual parts."

Two suggested methods for designing projects for resiliency were having more than one person working on the various components of a project and reducing the incentive for people to leave the project and go somewhere else. This incentive could be money, a bonus, or the choice of their next job. Several interviewees suggested that having scientists' funding tied inextricably to their integrated work may be necessary to keep motivation high and interest focused on the project. Another suggestion was that the time line for either individual modules of a project or the project as a whole might be geared toward participant goals.

"Find out what peoples' goals are in terms of time, and structure a project to fit them. If a person will mature and move along in their discipline in ten years but not in five years then structure their part of the project to be five years long."

Whether to spend most of the project money on senior scientists or on other things was also mentioned. Although it was clearly evident that many interviewees felt that senior scientists were better leaders for these projects and perhaps better able to think in an integrative manner, there were also some who felt that spending funds in other ways could pay off for the project in the long run.

"I would say keep away from the tendency to include a bunch of senior scientists who cost a lot of money and will only sign on for a month of time, that is a month of summer salary and who are lending their name more than anything else. Instead devote the money to younger people, who are more enthusiastic. And particularly the post docs who have had research experience so know the ropes a little bit and can devote all of their time, 100% of their time to the project, so that you can get a lot of stuff done."

"Don't be afraid to hire staff people. And particularly technicians who can facilitate the work of many people. As an example, someone who was doing computer animation and GIS work. We have a tendency in academia to want to devote all of the salary to academics, to grad students, to post docs, and to faculty. And I think that that is a mistake. I think that you can get far more bang for your buck from a program point of view if you realize that there are approaches and particularly graphic approaches that can be used by many people and rather than duplicate all that effort along all projects you can centralize things. Not only will you save money, but you will force people to integrate themselves more."

CHAPTER 7

SUMMARY AND DISCUSSION

7.1 INTRODUCTION

This final section will analyze the findings of the thesis, consolidate these findings under several broad themes, and discuss the future of integrated research as illuminated by these themes.

7.2 FUTURE INTEGRATED WORK WILL REQUIRE HARD AND SUSTAINED WORK BETWEEN SOCIAL SCIENTISTS AND BIOPHYSICAL SCIENTISTS

Resolving disciplinary differences will be one of the primary factors in determining whether integrated research will be successful in the future. An overarching theme that pervaded every interview was the different ways that social scientists and biological or physical scientists perceived integrated research. It was almost an insider versus an outsider difference, with social scientists often speaking in bitter terms about the processes involved in integrated research projects, while biological and physical scientists seemed to be much more in control, much more focused on outputs as opposed to process. Natural resource issues and problems are very much social problems involving significant human dimensions, and it seems clear that the social component in integrated projects is getting short shrift in both funding and projects as a whole.

For example, social scientists often made comments about how the social component in integrated research projects was an “add on,” and unanimously felt that this was a weakness in both project planning and implementation. Getting the various disciplines together in the problem-posing phase was viewed by social scientists as crucial to outcomes that would truly reflect the interactions of social components of ecosystems with the biological and physical. Biological and physical scientists were much less likely to recognize this as a necessary prerequisite to integrated research, and indeed often seemed to have given the matter little thought. Most biological and physical scientists projected an attitude of satisfaction with the interactions between the various disciplines on projects, and often had little to say when asked about conflicts between social scientists and biophysical scientists.

This lack of recognition of a serious problem appears to be a major stumbling block to successful integration. Social scientists are being vocal, both in person and in planned publications, about the ways in which integrated projects have to change in order to better reflect and incorporate social science data (For example, see McCool and Burchfield, 1999). But it is unclear if biological and physical scientists, who are often the leaders of these projects and represent the large share of researchers involved, recognize the depth of frustration that many social scientists feel toward the way integrated research is currently implemented.

Although funding agencies are beginning to provide increased opportunities for integrated research, inequities exist about their own priorities for true integration among social and biological science. Biological and physical components are almost always easier to plan for, to implement, and to translate to understandable numbers, maps, and statistical data, and this difference can translate to an emphasis on what is easier in a project instead of on what is most useful for society.

Some far-sighted administrators have recognized the need for better communication and understanding between social, biological, and physical scientists, and to this end have attempted some innovative techniques to accomplish these goals. All of these administrators, however, cite barriers--including lack of funding, institutional factors such as different reward systems, and lack of understanding on the part of biophysical scientists for what it is that social scientists do--that can work against what is ultimately a very time-consuming and sometimes painful process.

In sum, scientists who are serious about doing truly integrated research projects will need to find innovative ways for social scientists and biophysical scientists to communicate and interact with each other, before and during the course of the project. Although the best antidote for the chasm between categories of science might be just a willingness to learn about each other and develop mutual respect, those interested in integration between disciplines will need to take the lead on this. Some innovative researchers have initiated discussions to accomplish greater appreciation between disciplines, realizing this work can be a starting place.

Additional involvement of consultants or facilitators who specialize in bringing together members of diverse groups might be a worthwhile investment.

7.3 RECOGNITION OF THE INTEGRAL ROLE OF RELATIONSHIPS IS CRUCIAL TO INTEGRATED RESEARCH

Integrated projects, more than almost any other kind of research, require successful relationships. This is true from the relationships between scientists in different disciplines, to the relationships between administrators, leaders and scientists, to the relationships between team members.

The relationships between scientists from different disciplines may need the most nurturing. Social scientists described the lack of respect they felt emanated from biological and physical scientists, both for their methods and results. A feeling of not being valued was often seen as the underlying motivation for the lack of inclusion for social science in the planning process of integrated projects. Social scientists felt that the so-called "real" scientists imagined that the integration most important in projects was that between various biological and physical processes, with often the only "necessary" social science being economics, to measure the dollar impact of various options.

The disconnect between administrators and scientists noted in the research project may also best be countered by a recognition of the importance of cultivating better relationships between these two levels of project participants. As noted in the research, it was palpably apparent that administrators were much more likely to view their projects as being successful at integration, while research scientists tended to have a much more negative view. While the degree of involvement and responsibility for the project's success obviously influences this disconnect, better, more honest relationships between administrators and the scientists they oversee would result in better design of future projects. Administrators need not only to recognize the areas where projects were successful, but also need to actively seek and respect feedback from participating scientists so that future projects can build on the mistakes made and lessons learned.

Finally, recognition that leaders and team members need to be chosen based on their ability to create and maintain successful relationships is crucial to the success of integrated projects. Integrated projects cannot afford prima donnas or "grenade throwers," simply because of the tight interrelationships necessary between the various research components. If one or more individuals is unable to communicate with the other researchers or treat colleagues with respect, it can often mean the demise of a large part or even the whole of a project. One interviewee referred to this as similar to the domino effect; as one part of the project is unable to be completed or is done badly this in turn causes delays or holes in other parts of the project. Repeatedly interviewees mentioned the importance of having individuals who were dedicated to the project as a whole and not just to their own self-aggrandizement as necessary in forming the relationships that made integration possible.

The ability of leaders of integrated projects to form positive relationships also influences the success of projects to a great degree. Although leadership itself was expected to be rated highly given the literature review, the impact of the way that leaders formed relationships within and outside integrated research also affected projects. For example, it was generally acknowledged that those whom leadership trusted were the most likely to be asked to participate in integrated projects. Leaders wanted people that they had worked with before and knew to be able to both do the work and participate in research with the required amount of dedication to the project as a whole.

In hindsight, however, many leaders of projects interviewed acknowledged this might mean that talented and thoughtful individuals who were not known to the leaders might not be considered for participation. Further, the more the same people participate in integrated projects the fewer new ideas, new perspectives, and new methods might be considered for inclusion. In fact, one of the things the interviewer noticed was how often the same names came up when integrated projects—past, present, and future—were mentioned. An argument could be made that administrators and former project leaders need to carefully examine the criteria they use when choosing other leadership positions and researchers for their projects. Diversity in gender, race, disciplines included, etc., are desirable if integrated projects are truly to remain viable expressions of how the whole of human society interacts with the natural environment. Participation of those beyond the "good old boys" may also make integrated projects more acceptable to the diverse segments of society who ultimately decide whether to fund research. In the realm of private funding, leaders may need to be more vigilant to make sure that stakeholder interests do not determine what type of researcher is acceptable on an integrated project. For example, although lip service is often given to the importance of social science in integrated projects, several interviewees noted that very little import is given to disciplines such as political science or sociology whose work might shed considerable light on the interactions between humans and nature.

Finally, the relationships between team members in integrated research need to be carefully considered in order for this type of project to be successful. One of the most unexpected and salient findings of this study is the need to consider the personality of a researcher at least as carefully as the credentials that he or she brings to the project. Ability to get along with other researchers, to communicate in a positive way, to not be overly concerned with one's own success and to be a team player are all necessary characteristics for participants in integrated projects. Furthermore, processes for considering these personal characteristics need to be built into the selection procedure for integrated projects, which up to very recently have solely focused on academic credentials like publications or management agency variables such as who was available and willing to work in the designated area.

7.4 ONGOING MODIFICATION AND CHANGE IN THE STRUCTURE OF INTEGRATED PROJECTS WILL BE NECESSARY FOR FUTURE SUCCESS

If there were two themes that were echoed over and over again in the interviews conducted for this project, they were that integrated projects are subject to a steep learning curve, and that integration itself is a process, instead of an end. Although there was fairly wide recognition of these facts, there were few ideas generated about how to incorporate this knowledge into the structure of integrated projects themselves. Instead, questions seem to dominate this area. For example, how do integrated projects, which usually originate in admittedly entrenched institutions such as academia and resource management agencies, take into account the "learning curve" on these types of projects? What might be some ways that scientists can better learn from each other to improve their future projects? How do integrated projects, usually funded with a specific ending date, recognize and incorporate the idea that integration itself is never complete? What types of project structures will best work to insure that the continuing flow of knowledge will be recognized and utilized, and that knowledge gained in one project will be built upon in later projects?

One starting point from the literature review is that utilization of systems theory may facilitate more successful implementation of integration; the interviewees often implicitly endorsed systems approaches when analyzing the future of integrated projects. Systems approaches are based on ongoing knowledge and accounting for both recognized and unknown complexity, and as such could provide a framework for long-term integrated projects.

Incorporating a system approach into integrated projects would at the most basic level require the involvement of research leaders and administrators who understand the tenets and methods of systems theory. Although systems theory is more widely used in fields such as computer science, engineering, and business, there do not seem to be many natural resource practitioners in fields such as forestry who are well versed in systems theory or methodologies. Instead of attempting to conceive of the problem in an integrated fashion using creative methods, it often seems that researchers begin with pre-conceived ideas of what the problem is and which disciplines are necessary to solve it. From there, projects often seem to proceed in a linear fashion, thus precluding much inclusion of systems methods or ongoing learning and modification. A beginning step, therefore, would be for those who are in the first stages of conceiving integrated projects to either study systems theory or bring in practitioners from other fields who can facilitate incorporation of systems theory into integrated natural resource projects.

Once systems theory is understood by those beginning an integrated project, various types of systems methods could also be utilized to achieve better ongoing research results. One such approach involves a heuristic model, which is developed early on in the research process where knowledge of the problem may be limited. Identification of the problem and which appropriate scientific methodologies to employ in solving it are not preconceived; instead, brainstorming, Delphi techniques, and ongoing consultations with experts in many relevant fields are used to achieve consensus on problem identification and project methodology (Janssen and Goldsworthy, 1995).

Another approach involves building into projects the social constructs of many different stakeholders along with those of the supervising institutions, so that formulation of a problem is a composite of all the different versions, a combination of expert and non-expert opinions (Ison et al, 1997). Although programs like COPE employed this technique to some extent, the lack of a significant social science component combined with the absence of some stakeholders (for example, environmentalists) may have limited the extent to which the project findings fully and accurately described the system involved. Indeed, any natural resource integrated project that does not include a social component could be persuasively described as missing a key facet—no natural resource management problem today is unaffected by human dimensions (Shindler et al, in press).

Some researchers envision integration as eventually becoming the dominant paradigm in natural resource research and management (See, e.g., Clark et al, 2000). Findings from this study can help structure such programs. Funding during the beginning stages of the integrative project may be a major issue, as agencies or academic institutions may not be interested in paying for the time necessary in which disciplines come together to attempt to understand each other before ever even beginning to start on problem identification. To secure adequate funding, scientists will need to promote and demonstrate the value of using systems theory for solving the challenges of integrated research.

Agency and academic "turf battles" will also need to be addressed by those attempting integration. Since integrative science recognizes and values multiple points of view—both disciplinary and stakeholder—challenges to traditional expert authority may be an issue. Resources to encourage researchers in a disciplinary area to stay for the duration of a long-term project may also be effective to ensure that true integrated research can be accomplished.

These problems may be best addressed by the formation of special integrated research institutes, which could be associated with academic and management scientists but beholden to neither. An alternate idea within academia or agencies may be to design integrated projects with discrete cells within a large overall project. The goals for each cell would be self-contained, so that researchers and their graduate students could achieve their goals, get the necessary publications and professional mileage from their work, but the research would also contribute to the larger integrated project. This type of arrangement would involve a great deal of sophistication to properly design each cell to be both self-contained and contributory. A further advantage to this type of sophisticated organization, however, would be that the learning process could continue far beyond the contribution of one individual scientist or even one category of research. Conceivably, a continuing parade of stakeholders, scientists, and researchers could work on various aspects of an integrated project, doing their part and then passing the baton to new scientists who could learn from their work and then take this learning to the next level. This could only be possible, however, with strong, central leadership.

While integrated projects in the past have achieved some level of integration, maintaining inertia beyond the initial findings for continuous learning has proven a challenge. Findings from this study indicate that the structure of such projects and the interactions among participants will be integral to success over the longer term. As the linkages between humans and the natural world become more tightly interwoven, no one should expect that doing integrated research well will be an easy task.

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APPENDICES

APPENDIX 1
Interview Protocol

I. Integrated Research Concept

A. *One of the first elements I am interested in exploring is whether there are differing ideas among researchers as to what interdisciplinary, integrated research is and/or should consist of.*

- What does/did the term integrated or interdisciplinary research mean to you within the context of your project?
- Do/did you find that researchers in other disciplines have/had concepts/ideas of integrated/interdisciplinary research that differ from your own?
- If so, how would you characterize these?
- How do you think that your training has affected or shaped your view of what "integration" is?
- In your experience, are there any overarching conceptions across disciplines about what integrated/interdisciplinary research should consist of?

B. *Another aspect of integrated/interdisciplinary research is the initial decisionmaking process in which choices are made about disciplines and perspectives to include in the project, and processes for conducting research are delineated.*

- Do you know how the decision was made as far as which disciplines/perspectives to include in the project's integrated research
- Do you feel that the inclusion of these perspectives (and exclusion of other possibilities) drove the project's processes and outcomes, and if so to what extent?
- Would you include any other perspectives/disciplines if you had the research to do over again?
- How were the processes for research and integration chosen/decided upon?
- Who made these decisions?
- Would you change anything about this decisionmaking process and/or the results of the decisions?

II. Elements Which Affect Integrated Research

Another thing that is of interest to me is how researchers attempt to go about integrated research/work and what elements affect the process. For example, integrated research has been described as the process of *"synthesis of knowledge, approaches, and experiences into new and enriched knowledge areas."*

- Do you feel that the project that you worked on achieved this type of synthesis
- Why or why not?
- How did the project you were involved in attempt to go about making sure that the results were integrated? What kinds of processes were involved?
- How well do you think that the concept of "integration" was accomplished?

The context or question(s) to be answered and scale of the project would also seem to affect how integration is done within multidisciplinary research. One example which I have found in the literature of how context might affect the process comes from those who feel that because FEMAT was undertaken within the context of the desire to find an alternative that would pass judicial muster that this had a great effect on how the research/work was framed, implemented, and evaluated, and how integration was ultimately done. Scale is also seen by some reviewers as having a large impact on how integration is carried out; for example, the large geographic area in the ICBEMP is seen by some as influencing the degree to which integration was achieved and the way that the research was done.

- Has/did the context of your research project influence how integration was framed, how it was implemented, and how it was ultimately evaluated? If so, how?
- Has did the scale of your research project had/have a significant impact on how the integrated research was framed, implemented, and evaluated? If so, how?

III. Barriers to Integrated Research

A. *An aspect of integrated research that I am also interested in exploring is what barriers might exist in attempts to carry it out. For example, one oft-cited barrier to research across disciplines has to do with the differences in languages between researchers.*

- Did you find that barriers between disciplines existed in your attempt at doing integrated/interdisciplinary research?
- If so, how would you describe/characterize these barriers? How much did it have to do with barriers in communication between disciplines?
- Were there barriers related to different roles that individuals in the project played, i.e., managers v. scientists or scientists v. administrators?
- Did barriers exist related to "new" v. "old" scientists, in other words, those with more credentials v. those who had published less, etc.?

- Did barriers related to gender and/or power issues exist in the project?
- How did these barriers affect your attempt to do integrative research?
- What types of steps were taken to overcome these barriers?
- How successful would you deem these efforts?

B. *Another barrier to integrated research that I have encountered in the literature is obtaining funding and the funding process, so I want to touch upon the effect that this might have had upon your project.*

- How did the grant process and/or funding availability affect this research?
- What is your experience in trying to get funding for multi-disciplinary, integrative research?
- Do you find that a greater openness to integrated research is developing from funding sources and why or why not?

C. *Finally, other factors might exist which would seem to either hinder or promote successful integrated research. Some of the ones that I have read about include time allotment for the project, quality of leadership, and composition of the research team.*

- Do you feel that the time allotted for the research affected/is affecting its success/outcome? How so?
- Do you think that the quality and style of the leadership affected/is affecting the success of the research? How so?
- In your opinion did/has the composition of the team assembled to carry out the research affect[ed] either the research itself or how well integrated the final results were/are going to be?
- What other factors of importance would you cite which affect[ed] the success of the research and the degree of integration achieved?
- What recommendations would you have for researcher(s) who are planning to do a long-term integrative research project?
- If you were setting up this type of integrated research project how would you go about choosing a leader for it? How would you go about setting up the research team? What types of processes would you deem most important for inclusion in the project in order to achieve integration?
- Any other comments you would like to make or are there any questions of importance that I have left out?
- Whom else would you recommend that I talk to on this topic, either from the teams that you worked with or from people who might have good input on the project?

APPENDIX 2

Characteristics of Different Types of Interdisciplinary Research

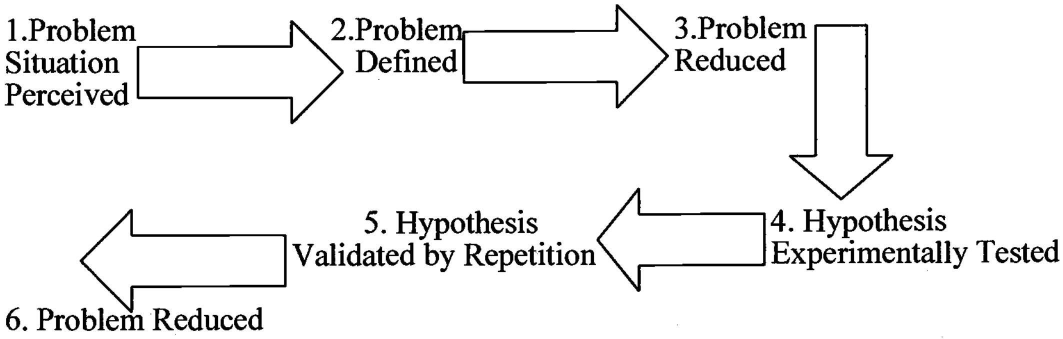
	Level of Integra-tion	Degree of Team Work Necessary	Personality Type	Problem Type	Complexity of Manage-ment
Additive	Little	Some	Focused scientists	Evaluation	Little
Integrated	Great	Great	Communca-tion oriented scientists	Diagnosis and evaluation	Some
Non-Disciplinary	Some	Little	Creative loners	Exploration of new problems	Great
Synthetic	Great	Great	Brainstormers	Discovery of new principles	Great

Adapted from Jansson and Goldworthy, 1996.

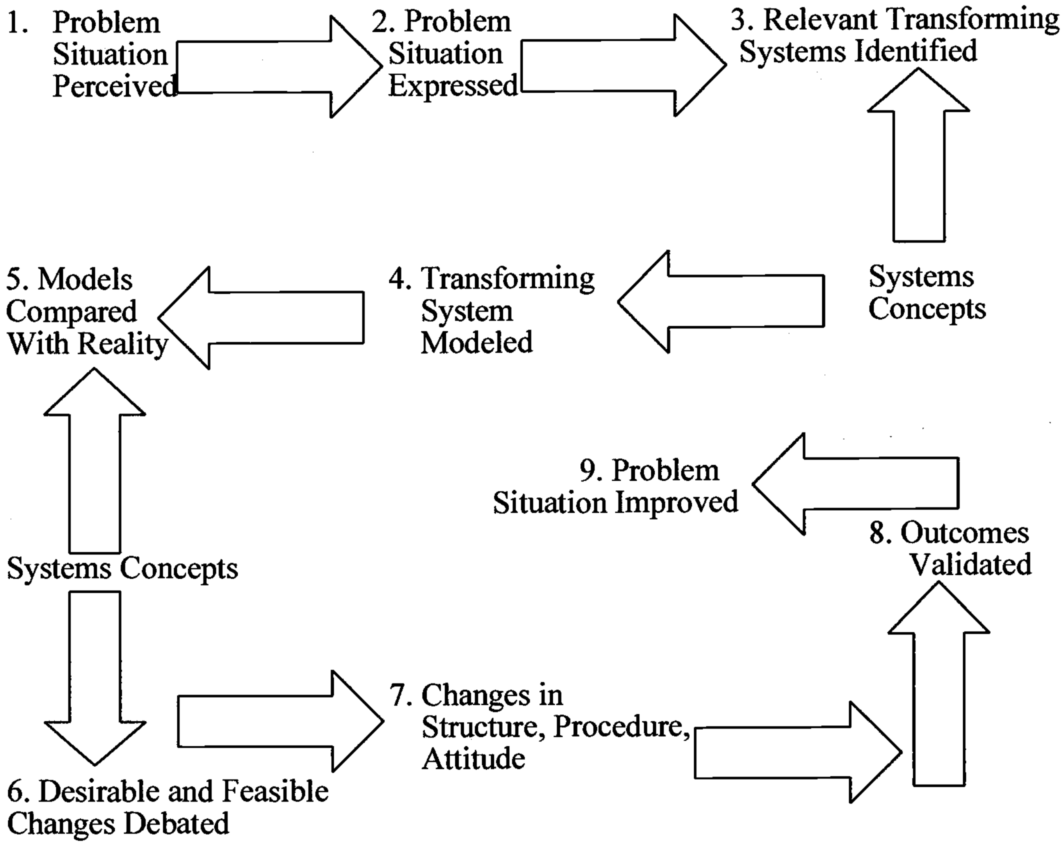
APPENDIX 3

Reductionist Approach v. Systems Approach

Reductionist Scientific Approach



Systems Approach



Adapted from Jansson and Goldworthy, 1996.

APPENDIX 4

Potential Responsibilities of Scientists, Managers, and Policy Makers in Bioregional Assessments and Integrated Research

Assessment Model	Role of Scientists	Scientific Credibility	Approximate Time Needed	Support from Managers
1. Scientists Assess the Situation and Develop a Management Plan	Philosopher-Kings	High	Small	Low
2. Scientists Develop Management Alternatives and Evaluate them	Policy analysts, policy makers	High	Small	Low
3. Scientists Evaluate current condition and trends; policy makers and managers develop management alternatives; scientists evaluate consequences	Policy analysts	Moderate	Moderate-Large	Moderate-High
4. Same as above, but scientists help develop alternatives	Policy analysts, contributors to policy making	Moderate-High	Large	Moderate-High
5. Policy Makers and managers develop alternatives and evaluate consequences	Bystanders, critics	Low	Moderate	High

Adapted from Johnson et at, 1999