USDA Forest Service Watershed Analyses:

A Lesson in Interdisciplinary Natural Resource Management

by

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USDA FOREST SERVICE WATERSHED ANALYSES:

A LESSON IN INTERDISCIPLINARY NATURAL

RESOURCE MANAGEMENT

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ABSTRACT

Recent thinking in natural resource management has led federal land management agencies such as the U.S. Department of Agriculture's Forest Service (Forest Service) to adopt ecosystem management as its official land management policy. A pivotal aspect of ecosystem management is interdisciplinary analysis of complex land management problems. Interdisciplinary watershed analysis attempts to engage in this approach and is intended to synthesize biological, physical, and socio-economic data in 20- to 200-square-mile watersheds in the Pacific Northwest. watershed analysis is carried out by teams of natural resource specialists from different disciplines.

However, interdisciplinary analysis by watershed analysis teams faces significant barriers to successful completion. One of these is a lack of research on how such analysis can become more interdisciplinary. Little research exists about interdisciplinary analysis by watershed analysis teams. Studies about benefits that the specialists and the agencies who conduct watershed analysis may gain are lacking as well.

This study identified and analyzed enabling factors, disabling factors and benefits of interdisciplinary watershed analysis carried out by Forest Service teams. Semi structured group interviews of sixteen watershed analysis teams were employed to obtain qualitative data about the topic. Qualitative analysis of group interviews, an open-ended survey and analysis of watershed analysis documents generated descriptive findings.

Primary enabling factors identified were use of geographic information systems, presence of an atmosphere of mutual respect, high-quality leadership and management support. Primary disabling factors included inadequate time and budget, difficulties with data, specialists' competing workloads and lack of management support. Benefits to the specialists and the Forest Service included enhancement of specialists' skills and

knowledge, specialists' acquisition of an ecosystem perspective, and better land management.

Primary recommendations included better planning for watershed analysis, enabling team members to have dedicated time to work on watershed analysis, and increasing agency-wide support for watershed analysis.

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Litigation from environmental groups over public land management policies and procedures, changing social values in regards to natural resources, and continuing environmental degradation have led land management agencies such as the United States Department of Agriculture's Forest Service (Forest Service) toward a new management paradigm (Grumbine 1994). In 1992, the Forest Service formally adopted ecosystem management as the direction future land management would take (U.S. Department of Agriculture Forest Service 1992). This move reflects a paradigmatic shift occurring in natural resource management (Brown and Harris 1992).

No longer does land management focus solely on single species or single commodity outputs. Instead, whole ecosystems are considered in land management practices. Slocombe (1993) characterized this approach as holistic and interdisciplinary, requiring new methodologies and input from many disciplines.

An important aspect of ecosystem management emphasizes the production of interdisciplinary analysis to drive decision-making (Wood 1994).

The mission of the Forest Service has changed prior to the shift towards ecosystem management. Since the turn of the century, the mission of the Forest Service has changed from that of conservation and caretaking prior to World War II to that of multiple-use, emphasizing timber production after 1950 (Kessler and Salwasser 1995). Each of these changes has reflected changing social values and legislation. Through the 1960s and 1970s, another shift of direction occurred, most notably in response to passage of legislation such as the Endangered Species Act, the Forest and Range Renewable Resources Planning Act, the National Forest Management Act and probably most importantly, the National Environmental Protection Act (Kessler and Salwasser 1995).

The National Environmental Protection Act required that the Forest Service incorporate interdisciplinary analysis into project planning. To complete land management projects, an environmental assessment was required in order to determine whether or not a proposed project would have significant environmental impact. A team of resource specialists (most often composed of a geologist, soil scientist, silviculturist, wildlife biologist, fisheries biologist and engineer) submitted individual reports detailing impacts to each resource. The team's documentation of impacts resulted in either a "finding of no significant impact" or "significant impact." If no significant impact was determined, an environmental impact statement was required. In National Environmental Protection Act terms, this is understood as a decision-making process where land management projects are carried out after environmental impact assessment. This process was multi-disciplinary rather than interdisciplinary. Specialists frequently advocated for their resource in this setting, creating a competitive, rather than cooperative, atmosphere.

The controversy over survival of the northern spotted owl (*Strix occidentalis caurina*) in the remaining old-growth forests of the Pacific Northwest has prompted the most recent shift in the Forest Service's mission. The northern spotted owl's range covers an area of more than twenty-four million acres in western Washington, western Oregon and northwestern California (See Figure 1). Since 1989, the Forest Service had been mired in controversy over this old-growth related species (Marcot and Thomas 1997). In 1992, the Forest Service organized the Scientific Analysis Team (SAT) to assess habitat requirements for the northern spotted owl and articulate a management strategy (Marcot and Thomas 1997). Simultaneously, a committee was put together to design a similar strategy for Pacific salmon stocks. This committee devised such a strategy and proposed a method for evaluating ecological processes in watersheds (Thomas et al 1993). This evaluation of function and process in a watershed was tentatively referred to as watershed analysis.

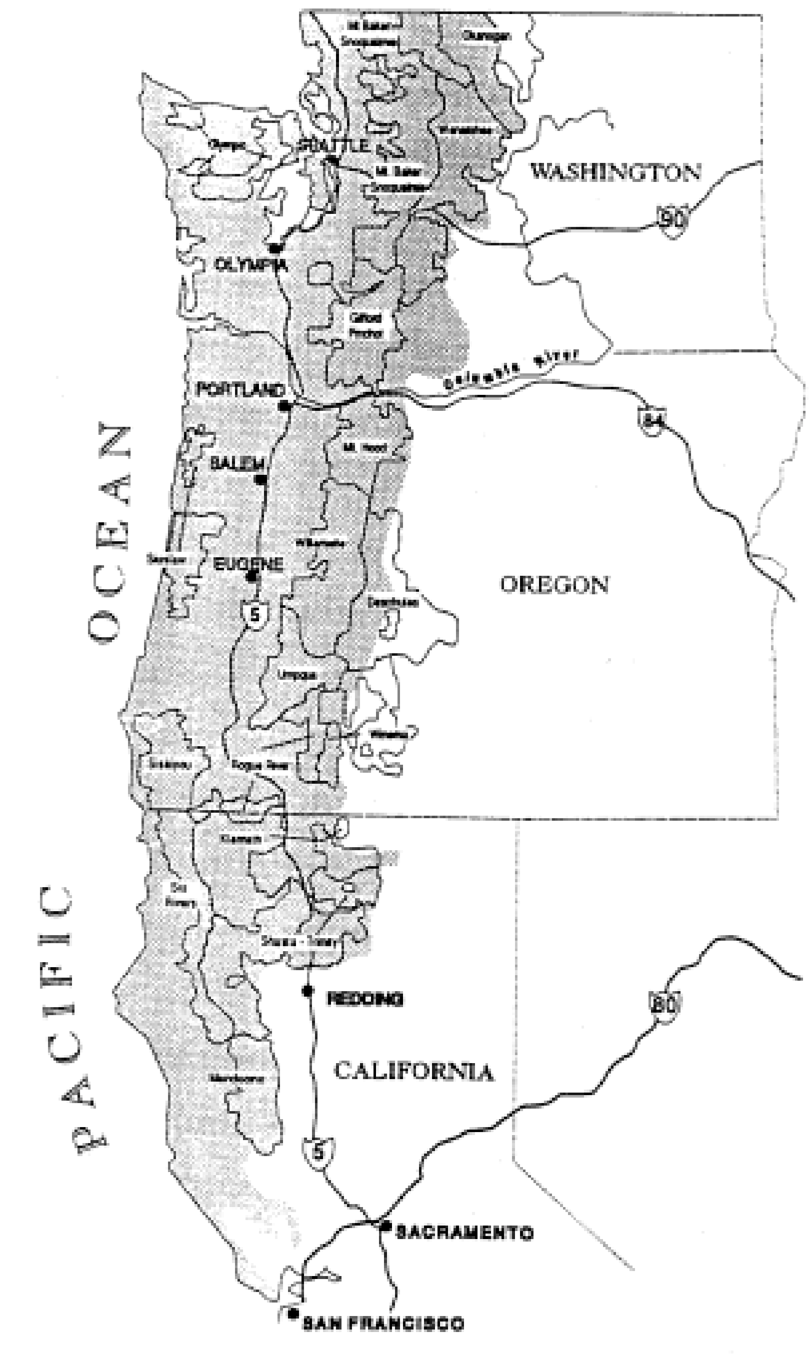

Figure 1. Range of the Northern Spotted Owl (from U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994a).

In 1993, President Clinton convened the Forest Conference in Portland to resolve the increasing controversy of social, economic and ecological issues swirling around northern spotted owl preservation. The result of the conference was the creation of the Forest Ecosystem Management Assessment Team (FEMAT). Many of the SAT members were on this team and many of the SAT recommendations were included in the resulting report, including watershed analysis (Forest Ecosystem Management Assessment Team 1993). The report presented and analyzed ten alternatives for ecosystem management on federal lands within the range of the northern spotted owl. Over three months, the team of over one hundred scientists headed by biologist Jack Ward Thomas struggled to produce alternatives which could fall within the President's seemingly impossible constraints. According to President Clinton, any plan must be "scientifically credible, legally defensible and ecologically sustainable" (Durbin 1998). The plan would also produce the maximum amount of timber within those constraints and examine the social effects of land management.

In 1994, an amendment was made to the planning documents of the Bureau of Land Management.(BLM) and the Forest Service throughout the range of the northern spotted owl (17 national forests in Washington, Oregon and Northern California and six BLM districts in Oregon). This amendment is variously referred to as the Northwest Forest Plan, or the President's Plan. The document signed on April 13, 1994, entitled *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl and Standards and Guidelines for Management of Habitat for Late-successional and Old-growth Forest Related Species Within the Range of the Northern Spotted Owl* (U.S. Department of Agriculture Forest Service and U.S. Department of the Interior Bureau of Land Management 1994a, hereafter referred to as the Record of Decision) prescribes ecosystem-management-based land management policy and practices, of which watershed analysis is a central feature.

The Record of Decision outlines an aquatic conservation strategy to "restore and maintain the ecological health of watersheds and aquatic ecosystems contained within them on public lands" (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994a) (Figure 2). An integral part of the aquatic conservation strategy, watershed analysis "characterizes watershed and ecological processes to meet specific management and social objectives" (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994a). To mandate watershed analysis, the Record of Decision declared that "timber harvest, including salvage, cannot occur in key watersheds without a watershed analysis. Ultimately, watershed analyses should be conducted in all watersheds on federal lands as a basis for ecosystem planning and management" (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994a). The entire plan area has 164 key watersheds (covering eight million acres), which are areas that provide (or are expected to provide) high-quality habitat for anadromous salmonids. These watersheds are essential to the long-term success of the aquatic conservation strategy.

According to the Federal Guide for Watershed Analysis, "watershed analysis is essentially ecosystem analysis at the watershed scale ... it provides the watershed context for fishery protection, restoration and enhancement efforts" (Regional Ecosystem Office 1995). Watershed analysis is one of the principal analyses that will be used to meet the ecosystem management objectives of the Record of Decision. Watershed analysis reflects the shift from "species and sites to the ecosystems that support them" (Regional Ecosystem Office 1995). This shift enables managers to begin to understand the effects of land management decisions prior to implementing site-level projects.

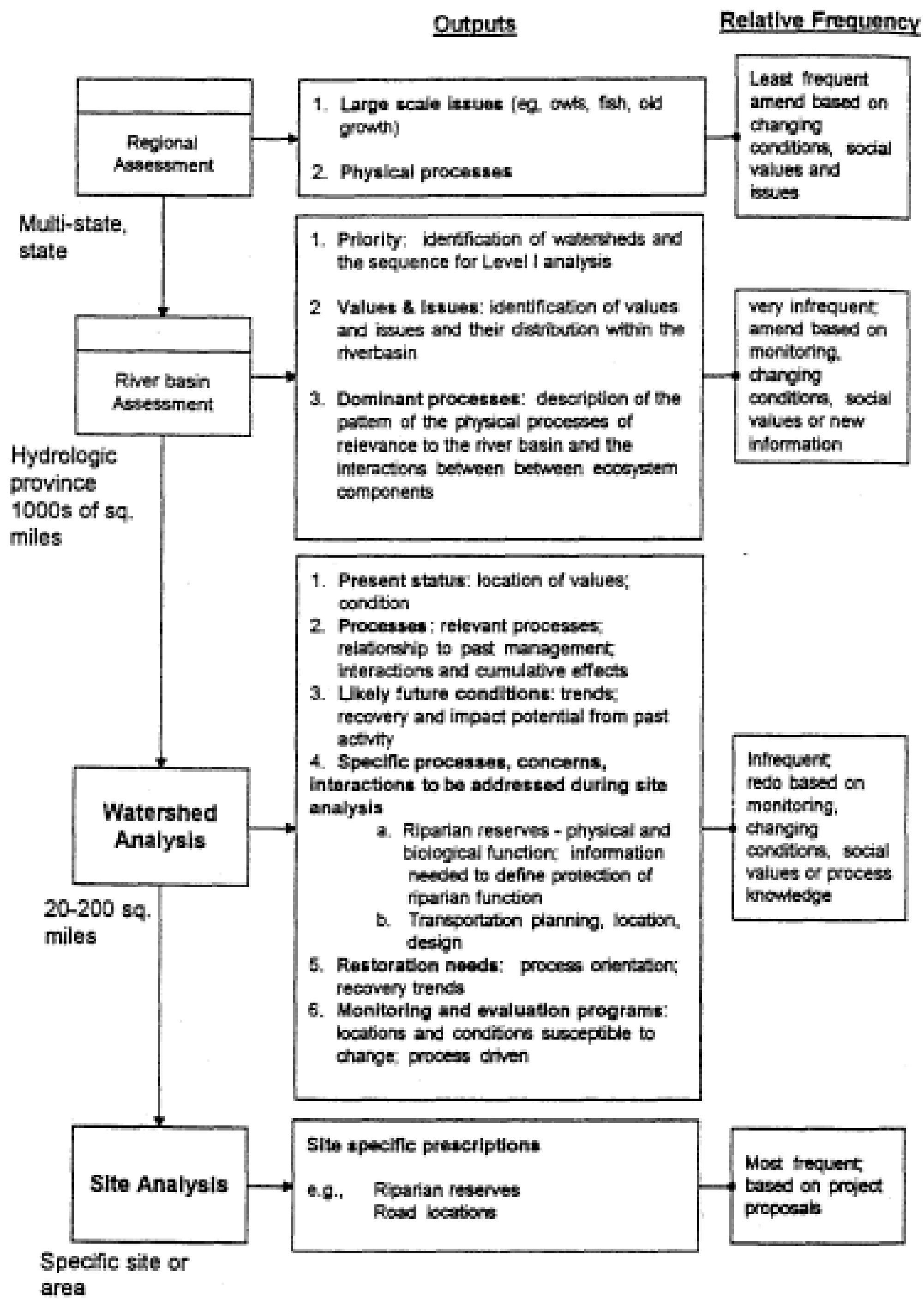

Figure 2. Context for watershed analysis (from Forest Ecosystem Management Assessment Team 1993).

Teams attempting to conduct watershed analysis, however, have encountered difficulty in making it a truly interdisciplinary process. This study, exploratory in nature, identified and analyzed enabling factors, disabling factors and benefits of interdisciplinary watershed analysis carried out by Forest Service teams. Semi-structured group interviews of sixteen watershed analysis teams were employed to obtain qualitative data. Qualitative analysis of group interviews, an open-ended survey and analysis of watershed analysis documents generated descriptive findings. In order to understand these results it is necessary to understand the watershed analysis process.

Overview of the Watershed Analysis Process

Watershed analysis describes watershed processes and functions in 20- to 200-square-mile watersheds. These processes and functions are not limited to hydrologic and aquatic phenomena alone. Watershed analyses detail social and economic aspects as well as upslope and terrestrial issues. The desired goal of watershed analysis is synthesis of various data to tell the story of a watershed in a way that can guide future planning. Watershed analysis is not a decision-making process requiring National Environmental Protection Act documentation. Instead, watershed analyses "serve as the basis for developing project-specific proposals, and determining monitoring and restoration needs for a watershed" (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994a). According to the original Forest Ecosystem Management Assessment Team report, watershed analysis "is both an analysis procedure and the first step in watershed planning. Fully developing and implementing watershed planning as a coherent step in ecosystem planning will require experimentation, learning, and the perspectives of a wide circle of individuals and disciplines" (Forest Ecosystem Management Assessment Team 1993).

Watershed analysis is an interagency approach. Watershed analysis is conducted by the Forest Service, the BLM and the National Park Service with participation by many other agencies (the Fish and Wildlife Service, the Environmental Protection Agency, Indian tribes, state and local resource agencies). A desired goal of watershed analysis is to engage land management agencies with each other to produce analyses valuable to whole ecosystems rather than arbitrary ownership patterns. This study concentrates on the application of watershed analysis within the Forest Service primarily on Forest Service lands.

Forest Service Watershed Analysis Teams. To better comprehend the watershed analysis process, it is important to understand the structure of the Forest Service and where the watershed analysis teams fit in. The Forest Service manages the National Forest System, which is divided into regions which are divided into National Forests. Forests are subsequently divided into Ranger Districts. Districts are the lowest level of the Forest Service organization chart (Figure 3).

The predominant function of districts is to carry out management activities ranging from road maintenance to surveying and managing species of fish, wildlife and plants. District personnel are organized into departments (e.g. engineering, lands, ecosystem management, minerals and geology, range, recreation, heritage and wilderness, forest management, watershed and air management, wildlife, fish and rare plants). Personnel are divided into line officers (referred to as "management") and staff (usually referred to as "resource specialists"). Department supervisors and the district ranger represent line officers at the district level and have decision-making authority. Staff report directly to supervisors who report directly to district rangers. Rangers in turn report to Forest supervisors at the Forest headquarters, who report directly to a Regional Forester. The chief of the Forest Service presides over the Regional Foresters. An

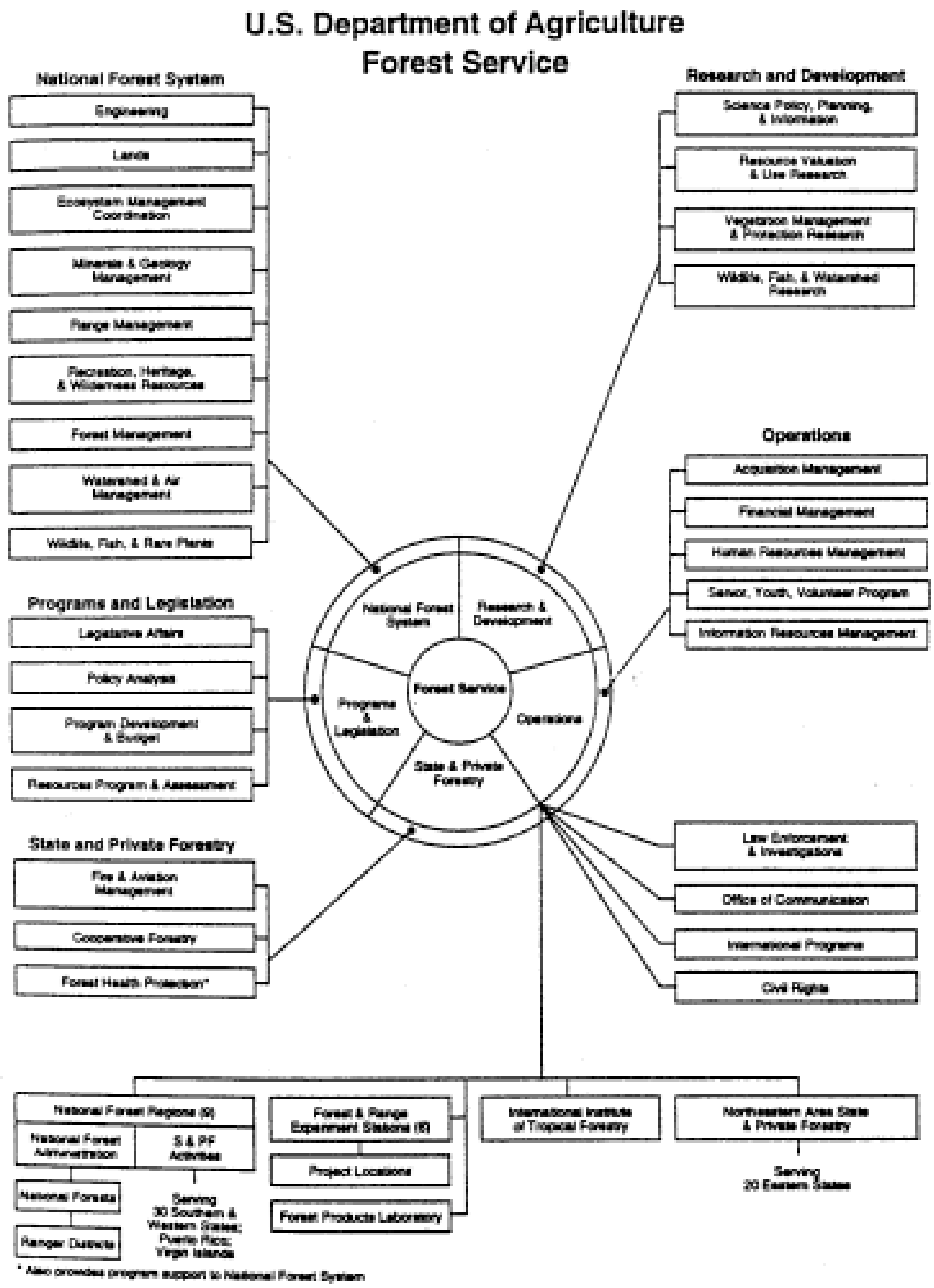

Figure 3. Forest Service Organizational Chart (from U.S. Department of Agriculture, Forest Service 1997).

additional overlay of this organizational structure was added with the implementation of the Northwest Forest Plan. Watershed analysis guidelines, for instance, were written by the Regional Ecosystem Office, an interagency entity set up to coordinate and set policy for the Northwest Forest Plan.

The watershed-scale interdisciplinary focus is new for district resource specialists. Resource specialists' interdisciplinary work to date has been predominantly on interdisciplinary teams for National Environmental Protection Act documents (such as environmental assessments and environmental impact statements). The Federal Guide states that the teams which conduct watershed analysis, "should include interagency and interdisciplinary resource specialists appropriate to the issues, ownerships, and respective jurisdictions within the watershed" (Regional Ecosystem Office 1995).

Given the complexity of issues and key questions in any given watershed, it is easy to see why an interdisciplinary team is required to analyze and synthesize various data to find the crucial interconnections in a watershed. Interdisciplinary watershed analysis has the potential to move beyond single species or single output resource management to a more complete understanding of ecosystem and watershed interactions. Watershed analysis represents this new type of thinking and is for many district personnel, their first involvement with ecosystem management.

Watershed analysis teams are usually composed of resource specialists in the district, although some Forests employ a "dedicated team" out of the Forest headquarters. Dedicated teams work primarily on watershed analysis, whereas district teams are not exclusively devoted to watershed analysis. District team members simultaneously work on any number of other projects. Dedicated teams generally maintain the same team member composition over time, whereas district team memberships change.

District team membership is frequently determined by necessity rather than choice due to limited budgets and lack of specialists in some districts. If a resource specialist is missing or unavailable on the district, a Forest-level specialist may join the team. There is usually a core team composed of the specialists that work most closely together to integrate various data and to write up the completed document. Other specialists make up an extended team which provides more limited input on particular issues or subject areas or carries out specific assignments. Both core and extended team compositions vary widely in disciplinary representation, but are generally selected to be appropriate for the relevant issues of the watershed.

Watershed analysis teams are led by a team leader who does not have supervisory authority over specialists. Frequently, team leaders have little or no experience in leading interdisciplinary teams.

Generally, watershed analysis is set aside for other priorities, although watershed analysis can become a "hot" priority when projects need to be completed in the watershed (e.g. timber sales). However, when other priorities take precedent, watershed analyses may be put on hold for extended periods. Many watershed analysis teams change compositions during their lifetime for precisely this reason.

Additionally, district teams are shuffled between watershed analyses when multiple watershed analyses are conducted on a single district. Team leaders change, staffing changes and timelines change. A wildlife biologist, for example, may leave a district between watershed analyses, to be replaced by another specialist. Combination teams of district and forest personnel face the additional challenge of scheduling. Setting meeting dates can become a challenge. Recent downsizing and "zoning," where specialists have responsibilities in two districts, make proper staffing a challenge at times.

Watershed Analysis Process. Teams follow the six step process outlined in the Federal Guide (e.g. characterization of the watershed, identification of issues and key questions, description of current conditions, description of reference conditions, synthesis and interpretation of information, recommendations).

First, specialists identify the defining physical, biological and social features of a watershed. They also identify the land allocations, Forest Plan objectives and regulatory constraints in the watershed. Second, the team focuses the analysis on the key elements of the watershed that are most relevant to plan objectives, social values and resource conditions. Additionally, teams solicit public input during this step in order to identify the important issues in a watershed. Third, specialists detail the current conditions of the watershed (usually by discipline). Fourth, the team describes the historical conditions of the watershed. Fifth, the team synthesizes and interprets current and reference conditions and attempts to explain differences, similarities and trends. Lastly, the team makes management recommendations. Generally, specialists collect data and write reports individually for steps one, three and four. Steps two, five and six are performed by the core team with input from the extended team.

The team produces a document that has an audience composed simultaneously of the public, resource specialists and the district ranger. The watershed analysis document assists resource specialists in preparing National Environmental Protection Act documents for project planning. It also gives guidance to the district ranger who makes management decisions on Forest Service land in that watershed.

The Federal Guide states that finished documents are to be reviewed through a scientific peer review process "to evaluate the scientific credibility and adequacy of watershed analyses. Such reviews could provide important feedback on whether analyses were based on sound scientific information, provided useful recommendations to managers, and met the requirements of existing plans and direction" (Regional Ecosystem Office 1995). To date, no formal review has been completed.

The Federal Guide does not specify a timeline for completion of watershed analyses, merely a pie-chart which suggests the relative duration of each of the six steps (Regional Ecosystem Office 1995). As Reid et al. (1996a) note, this has led to some conflict between specialists whose "desire for detail and precision argues for a lengthy time commitment" and managers who "see watershed analysis as a hurdle to be leaped before any activities are carried out."

Watershed analysis is an iterative process rather than a one-time analysis. Watershed analysis teams use available data to begin but benefit from knowledge gained as projects are implemented in the watershed. This adaptive approach shuns a static approach to resource management in favor of a dynamic, ecosystem-based approach which more accurately reflects the ever-changing nature of the landscape, and which tackles issues of importance to the public, land managers and resource specialists.

Enabling Interdisciplinary Analysis

Interdisciplinary analysis is by no means new. It has been employed in the U.S. in universities, government and private industry since the early part of the 20th century (Klein 1990). Research on interdisciplinary analysis teams dates back to the 1950's and peaked in the late 1970's and 1980's. There has been a recent resurgence of interest in interdisciplinary approaches (Klein 1990, 1996).

While monodisciplinary analysis on its own is necessarily restrictive (Bella and Williamson 1976, Regier 1978), interdisciplinary work focuses the attention of a group of diverse specialists on one particular problem. The analysis becomes interdisciplinary when the group coordinates its investigations around a higher-level concept than individual disciplines provide (Regier 1978).

Watershed analysis most closely resembles "problem-focused interdisciplinary research" (Klein 1990). Problem-focused interdisciplinary research is not "pure" research due to its origins in some outside institutional agent or social force. The primary strength of problem-focused interdisciplinary research is the ability to solve problems that researchers from a single discipline could not solve alone. Problem-focused interdisciplinary research is "research involving input from several disciplines and with the effort mutually planned, executed, evaluated, conclusions drawn and results disseminated" (Russell 1982a). An interdisciplinary approach tends to promote advances in methods and analytical tools as well as enabling professional development of specialists (Russell 1982a).

Problem-focused interdisciplinary research offers a means of investigating larger and more complex problems than can be undertaken by a single investigator or by a team from one discipline (Luszki 1958). Potential results of interdisciplinary cooperation include fostering new patterns of scientific discovery (Luszki 1958) and enabling team members to gain a broader perspective of the object of study (Francis et al. 1982). Problem-focused interdisciplinary research produces results that exceed the sum of disciplinary contributions and more holistic understanding of resource problems (Bella and Williamson 1976).

Problem-focused interdisciplinary research does pose problems despite its strengths. A lack of shared methodologies and theories about problem-focused interdisciplinary research makes this type of research especially challenging (Klein 1990). Russell (1982a) states, "If problem-focused interdisciplinary research were easily accomplished, it would probably be the prevalent mode of research. But given the organization of science, complexities of research funding, and the professionalization of scientists . . . problem-focused interdisciplinary research is accomplished only with great commitment and much effort."

The specifics of problem-focused interdisciplinary research origination, organization and purpose require researchers to create unique research methods (Chubin et al. 1986). Accordingly, there are no widely accepted models for problem-focused interdisciplinary research. The literature of problem-focused research tends to be problem-driven and dominated by case studies. Many of these studies are in academia and the service professions (health care, education) with few natural resource management cases (Klein 1990). However, a number of sources identify enabling factors of problem-focused interdisciplinary research efforts. Enabling problem-focused interdisciplinary research involves planning, good team interaction and institutional support (Klein 1990).

Planning for interdisciplinary analysis. A study of an interdisciplinary ecosystem-level restoration project documented the importance of interviewing participants before they join a research team to identify expectations and biases they bring to the group (Stefanovic 1996). Eisenstat (1990) illustrated the importance of setting organizational directives early on in the planning process. Eisenstat (1990) demonstrated the importance of all members sharing their version of what a successful project would look like. Team members must be clear in articulating accessible goals and how data can be examined from differing disciplinary viewpoints (Gersick and Davis-Sacks 1990).

Early in the project, ground rules must be set as to what perspective the team is looking at a problem (Bella and Williamson 1976). If these rules are not set, disciplinary contributions can be of improper detail for the broad vision a project seeks to discover. This does not mean that high-detail disciplinary work should be thrown out. To the contrary, high detail work is needed in addition to the broad perspective. Frequently it is the working together of specialists which enables the formulation of a broad view "big picture" of an environmental problem (Bella and Williamson 1976).

Team Interaction. Team interaction is fundamental to successful problem-focused interdisciplinary research. Teams need to see the results of their work, however small (Perkins et al. 1990). The feeling of ineffectiveness can inhibit team members from participating fully. Organizational or agency directives should reward team members for seeing and presenting ways that the analysis can make a difference in long or short term projects (Luszki 1958, Klein 1990).

Individuals (and especially scientists) must become accustomed to working in teams (McGrath 1984, Hackman 1987). Academic training is generally dedicated to individual research and little attention is given to the development of skills necessary to work in groups. It is important, however, for agencies or organizations sponsoring problem-focused interdisciplinary research to have guidelines and training in place for team work (Hackman 1987).

Total quality management principles have been demonstrated to be effective within interdisciplinary work teams (Goepp 1994). First, teams need to tailor their research programs and recommendations to the specific needs of an organization. Effective communication between teams and the recipients of research creates more valuable research products. Second, effective interdisciplinary teams employ effective leaders who challenge members to engage in meaningful learning, inquiry and problem solving (Goepp 1994). Third, interdisciplinary teams must provide broad-based forums where no one is slighted or encouraged not to contribute. Mutual respect is the basis for creating such forums (Luszki 1958).

Coordinating specialists of different disciplines is a challenge for problem focused interdisciplinary research. Teams should be selected to optimize problem-solving (Regier 1978). Different resource disciplines have unique underlying concepts which may prevent interdisciplinary work. It may take a significant period of time to move beyond these differences. "One should not expect to achieve significant progress quickly by convoking an interdisciplinary team that consists of team members from disciplines whose relations to uncertainty, expectation and variability are highly variable" (Regier 1978). Interdisciplinary research progresses optimally when there is a reduction of differences in semantics between disciplines represented on a team and there is adequate representation of necessary disciplines (Regier 1978).

Luszki (1958) identified several desirable qualities individual specialists should have before joining a problem-focused interdisciplinary research team. Team members must have adequate professional training, experience working together, a common denominator of knowledge, and some previous experience with interdisciplinary teams. Selection of team members who think too much alike, however, can be bad as "groupthink" can result (Harper and Riflcind 1995).

Personalities of individual team members are critical to success or failure of a problem-focused interdisciplinary research effort. "In problem-focused interdisciplinary research, personality factors are more important than in other kinds of research because the frustration from material, financial, scientific and emotional problems is usually greater" (Luszki 1958). Team members simply have to come to grips with one another. Informal settings can frequently be key places for team members to integrate (Luszki 1958, Epton et al. 1983). It's best not to try and integrate a person who simply does not work well in teams (Luszki 1958).

Another pitfall teams face is decision making. Consensus may seem desirable, but it may force agreement prematurely. Luszki (1958) suggests that premature consensus can create an "illusion of friendship" which may ease the team through rough decisions, but prevent a real understanding of each other.

Proper working conditions can be a major enabler of problem-focused interdisciplinary research. Easy association between team members can result from good physical working conditions (Luszki 1958). These conditions build "rapport and provide a certain amount of office happiness . . . good facilities are good not only for morale, but for communication, status and direction, as well as for creative thinking" (Luszki 1958). Optimal working conditions for problem-focused interdisciplinary research include: (1) all team members should be in the same building, (2) team members should be located functionally in relation to each other, rather than grouped by discipline, and (3) the team must have a room with a large table, a blackboard, and a coffee pot (Luszki 1958).

Teams should display project material from different disciplines (Luszki 1958). These displays of progress are important and should be ongoing rather than only at specified intervals. Team members can get acquainted with other specialists' progress and questions continuously rather than waiting for meetings. These factors may seem trivial, but are often overlooked and can contribute substantially to good work.

Team Size. Small groups with stable memberships appear to be the most integrative, though large groups with stable membership may have positive results as well (Klein 1990). Larger groups have more difficulty integrating their findings. The administrative costs and logistical difficulties are higher as well. There is a need for balance, however, between needing adequate representation of appropriate disciplines and having too large of a team.

Smaller teams benefit from spending more time on actual research. Coordination and communication between team members is easier in small groups. However, a larger team has contributions from more disciplines. Therefore, the problem is better covered and the research is potentially more powerful and effective. These advantages may outweigh higher administrative problems and costs (Russell and Sauer 1982).

Personnel retention is extremely important in problem-focused interdisciplinary research efforts. "It often takes a year or longer for an interdisciplinary team to function at full efficiency. It seems wasteful of research resources for a group that has attained a high level of effectiveness to be abandoned at the end of a single project" (Luszki 1958).

Institutional Support. Often a problem-focused interdisciplinary research team has little research orientation and no acceptance of the uncertainties of research. "Researchers are prepared for "no answers" as a result of research expenditures, but the [agency] with little understanding of research expects to receive something for the money invested in a research project" (Luszki 1958). Objectives and expectations defined in tandem with the sponsoring agency increase a team's effectiveness (Russell and Sauer 1982). Agencies sponsoring problem-focused interdisciplinary research must be open to research findings (and non-findings). Problem-focused interdisciplinary research teams have greatest success when they have a free hand in trying new methods (Luszki 1958). Likewise, teams operate best when research results are not limited by pre-determined strictures set forth by the sponsoring agency (Klein 1990). Teams (especially science-driven teams) succeed when it is clear that the results of their research will not simply be ignored in favor of agency pre-conceptions (Russell and Sauer 1982).

Institutional support involves providing adequate time, money and other resources (Luszki 1958). Initial agreement on a project budget and regular review of that budget is essential to a project's success (Russell and Sauer 1982). Once underway, problem focused interdisciplinary teams should communicate regularly with agency personnel (Luszki 1958). Successes, failures and needs of the team should all be communicated on a regular basis. This communication tends to produce satisfactory results (Luszki 1958).

Problem-focused interdisciplinary research teams need review and feedback of progress and products in order to succeed. Quality control of problem-focused interdisciplinary research products by individuals outside the team creates better products (Goepp 1994). Peer review enables teams to gain valuable feedback on methods and findings, but also generates a feeling that the research is important (Luszki 1958, Klein 1990). Standardization may be desirable, but difficult to achieve for problem-focused interdisciplinary research (Russell and Sauer 1982).

Research on Watershed Analysis

Watershed analysis has been carried out since 1994. To date, over two hundred watershed analyses have been completed, with no formal review and no studies of the teams which carry them out (Reid 1996). Research on watershed analysis is limited, largely due to its novelty and specificity. Although research exists concerning methods teams can use to assess watershed characteristics (Frissell et al. 1993, Reynolds et al. 1996, Kasperson et al. 1996), research on interdisciplinary teams which carry out watershed analysis is more limited.

An interagency conference was held in 1994 in Eugene, Oregon, to assess the results of the original pilot analyses and update watershed analysis guidelines (U.S. Department of Agriculture, Forest Service and U.S. Department of Interior, Bureau of Land Management 1994b). At this conference, a working group entitled "Synthesis of Individual Disciplines" identified several concerns team members had about the interdisciplinary aspect of watershed analysis. In particular, participants noted that the stumbling blocks to watershed analysis had to do with the way the Forest Service approaches land management. The partial transition to ecosystem management was incomplete. Watershed analysis was identified as an ecosystem management-oriented analysis being conducted in a largely non-ecosystem management environment. Interdisciplinary analysis was not completed as a result (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994b).

Watershed analysis also needs interdisciplinary analyses incorporated throughout the process (U.S. Department of Agriculture, Forest Service and U.S. Department of the

Interior, Bureau of Land Management 1994b). Reid et al. (1996b) agreed, adding that deferring interdisciplinary analysis until the end of the process disabled synthesis for the majority of the watershed analysis process. Adequate time is also necessary for interdisciplinary analysis to occur. Many watershed analysis efforts have failed to produce good synthesis because of time constraints (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994b).

Members of a Forest Service team noted that finding links between disciplines was the most critical factor to success, while team members having too many other responsibilities was the major barrier (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994b). Other recommendations relative to the interdisciplinary aspect of watershed analysis from the Eugene conference included: There should be better articulation of the vision of watershed analysis, better use of team teaching, more work on improving communication skills (especially on interagency watershed analysis) and more effort to identify ways to better integrate data in watershed analysis.

In an examination of several completed watershed analyses, Trail (1995) noted that watershed analysis suffers from a lack of standards and mechanisms for evaluation. Without evaluation, watershed analyses are simply accepted by district rangers, and teams have no way of knowing what represents a good watershed analysis product.

The watershed analysis process is also impeded by a low level of managerial and political commitment (Montgomery et al. 1995). To be successful, planning must be predicated on the findings of watershed analysis, otherwise the costs incurred in watershed analysis production are not justifiable. If watershed analysis is not integral to planning, no one will buy into the process, which can make the products worthless. Additionally, watershed analysis needs to have clearly defined objectives and sufficient time and staffing to produce results adequate for planning (U.S. Department of

Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management 1994b).

Reid (1996) saw "a humbling array of analytical, cultural and procedural barriers" to enabling interdisciplinary watershed analysis. First, resource specialists have a hard time integrating different disciplines. Specialists are accustomed to the specialized knowledge of their own disciplines and unaccustomed to the generalized knowledge that watershed analysis seeks to produce. This "reverence for specialization" is at direct cross-purposes to interdisciplinary analysis (Reid 1996). Individual team members write specialized reports (e.g. geology or soils or social dimension) which entirely ignore concerns of other disciplines relative to their disciplines. Second, Forest Service culture lacks an interdisciplinary analysis orientation in its field offices (Reid 1996). Line officers and staff are unfamiliar with watershed analysis and its interdisciplinary research orientation. Third, clashing personalities on watershed analysis teams decrease interdisciplinary teamwork. To date, specialists have been segregated by function. Timber specialists and wildlife specialists, for instance, have held adversarial relationships. Interdisciplinary work is sometimes marked with discord between these perspectives. Fourth, misunderstandings between specialists of varied training reduce interdisciplinary effectiveness. For example, concepts familiar to wildlife biologists may be poorly understood by hydrologists. Retention of disciplinary jargon and methods disables interdisciplinary analysis (Reid 1996). Fifth, limited funding and a competitive funding system decrease feelings of collegiality between specialists.

Reid (1996) offers some solutions to the above barriers. One approach is to carefully select team members. People with broad interests, curiosity and without big egos are good choices. Participants must be able to explain concepts from their own disciplines to other team members and relate them to concerns of other disciplines. Self-confidence is an essential ingredient as team members must not be afraid to admit they do not know everything in their own or any other field. Members must be willing to learn from each other and to recognize their own knowledge gaps.

Another strategy for promoting interdisciplinary work is related to the original watershed analysis guidelines. This approach proposes that the team design the analysis so that an interdisciplinary approach is required (Reid 1996). Focusing on the issues in a watershed rather than attempting to reduce the watershed to its disciplinary parts is one method for accomplishing this.

Another approach involves five organizing concepts for successful integration (Reid 1996). All team members must share a common vision of the watershed analysis. All must be clear on the importance of working in an interdisciplinary manner. Team teaching is employed to promote interdisciplinary analysis. Team teaching involves each specialist teaching the team about the watershed from their disciplinary point of view. Teams organize field trips to show each other what they are referring to. Teams then utilize flowcharts to identify the most important functions and processes and to prioritize data needs. Lastly, rigorous editing produces a clear and concise finished document. The resulting product can be more than the document produced: "specialists broaden their understanding of the ecoscape as a whole [and] they become better equipped to solve problems even within their own fields" (Reid 1996).

In an attempt to provide insight into the interdisciplinary aspect of watershed analysis, Caraher (1996) articulates three techniques to be employed into each of the six steps of the watershed analysis process. Team members bring significant findings to team meetings. Coming to team meetings with such findings makes it easier for other team members to digest the information and concepts being presented. Team members then sketch this information onto a base map of the watershed. This map helps facilitate interaction between team members by offering a visual image of a specialist's ideas. At the end of each step, the team looks again at all the condensed findings and sketched maps. The team might then detect heretofore invisible relationships in the watershed.

Reid et al. (1996b) state that "after two years of interagency watershed analysis, many analysis products show little evidence of synthesis having taken place." They link this to the progressive refinement of the watershed analysis guidelines which were intended to make watershed analysis more "do-able" for teams. Following these guidelines, the teams fell back into National Environmental Protection Act techniques in which each specialist writes his or her section and a writer/editor integrates the data. Synthesis doesn't happen until step five of the updated guidelines, leaving interdisciplinary analysis out of two-thirds of the analysis. Indeed, the guidelines encourage interdisciplinary analysis, but without really demonstrating how. According to Reid (1996), a "major challenge for analysis teams is thus to find ways to promote interdisciplinary teamwork."

METHODS

This research attempts to discover factors which enabled and disabled interdisciplinary watershed analysis conducted by the U.S. Department of Agriculture Forest Service (Forest Service). The study also sought to discern benefits of watershed analysis to resource specialists and the Forest Service. The research setting is the Pacific Northwest, in ranger districts on National Forests affected by the Northwest Forest Plan (See Figure 1).

Qualitative research techniques were employed to explore the enabling and disabling factors that teams faced when conducting watershed analysis. The novelty of watershed analysis in the Forest Service, lack of formal review and limited research dictated this approach. Qualitative research is ideal for applied research of topics where key indicators for measuring success are not well understood (Patton 1990). Several methods were employed to reinforce one another to provide triangulation to strengthen conclusions (Janesick 1994).

<u>Group Interviews.</u> Group interviews were used because the research was exploratory. Group interviews serve phenomenological purposes when conducted in a semi-structured fashion in the field (Fontana and Frey 1994). A set of interview questions was employed to guide discussion only (Appendix A). The interview was informal, to fully explore the topic as well as setting participants at ease. The interview was a conversation with a purpose (Marshall and Rossmann 1989, 82). Group interviewing was a useful way to gain knowledge about this unstudied phenomenon when the researcher did not know all of the issues surrounding a particular topic (Patton 1990). Group interviewing also permitted immediate follow-up questions and discussion of a wide range of information and subjects (Marshall and Rossmann 1989). This ability was seen

as desirable because of the complexity of interdisciplinary analysis and because watershed analysis was interwoven with other issues. More importantly, it provided an opportunity to get a feel for the attitudes of team members as well as an understanding of their working environments.

The sample of group interviews was procured using a combination of snowball sampling (contacting experts in the field to identify excellent teams to interview) and purposive sampling of teams (reading watershed analysis documents first to identify teams with high or low levels of interdisciplinary analysis). Snowball sampling is effective when a researcher wishes to gain access to a particular segment of an organization (Babble 1992). Purposive sampling is especially useful in group interviewing when groups are difficult to assemble (Babble 1992).

Some team leaders or district rangers were not interested in participating or would not arrange time for an interview. After a great deal of persistence, sixteen interviews were arranged on districts throughout the Pacific Northwest. The final sample of teams consisted of teams willing to be interviewed, thus, the sample was non-random.

Fifteen semi-structured group interviews were conducted on-site at eleven Forests (eleven ranger districts and two Forest headquarters) and one Bureau of Land Management resource area over the period August 17 to September 10, 1998. One additional interview was conducted as a telephone conference call on September 16, 1998. The interviews lasted between one and one and one-half hours. The interviews were conducted in meeting rooms at district offices, which provided relatively quiet settings. Interviews were recorded with a microcassette recorder and detailed notes were also taken.

The issue of informed consent was addressed with a confidentiality waiver. Prior to the interview, subjects were informed that their names would not be used in this paper. The identities of all subjects are protected as much as possible in this paper.

A total of seventy-three people (group average was four, maximum was eight and minimum was one) were interviewed. Team member disciplines ranged from archaeology to wildlife biology. Most frequently represented were wildlife biologists (12), fisheries biologists (11), silviculturists (11) and hydrologists (10).

A pre-interview survey of the teams was administered prior to group interviews (Appendix B). These data were intended to further enrich the interview data and to obtain responses from individuals who are more articulate on paper than speaking in a group. Also, the data provided background information on team members and team interactions to the interview. A total of sixty-nine pre-interview surveys were received.

Additional background research on the watershed analysis process was conducted prior to the group interviews. An interview with a district ranger to gain a line officer's perspective was conducted. A public forum in which discussion focused on watershed analysis issues was attended (a provincial advisory council meeting). An in-depth interview with a team leader who had experience as team leader on five watershed analyses was conducted. An active watershed analysis team was observed during one of their synthesis meetings. An initial "practice" group interview with a watershed analysis team was held. Reading of completed watershed analysis documents from throughout the study area was completed.

Data Analysis. Recordings of the interviews were transcribed and compared with notes. Enabling factors, disabling factors and benefits that were repeated in transcripts of group interviews and notes were condensed into a matrix and similar responses classified and tallied. Results are presented qualitatively. Descriptive statistics are presented to reveal the "dominance" of a particular factor. However, because this is exploratory research and teams were not selected randomly, further conclusions should not be drawn from the statistics presented.

Results are presented in three categories. Enabling and disabling factors are presented. Each category is sub-categorized into internal and external conditions (Klein 1990). Internal conditions include techniques, team dynamics and personality issues. Techniques refer to activities and strategies teams employed to conduct interdisciplinary analysis. Team dynamics are defined as types of team interactions which include the whole team. Personality issues deal with issues related to individual team members.

External conditions include logistics, resources, institutional issues and document issues. Logistics include technical aspects of coordinating a watershed analysis. Resources are temporal and budgetary constraints. Institutional issues are dynamics between team and agency. Document issues are issues pertinent to the product of the finished watershed analysis document.

Benefits of interdisciplinary watershed analysis are responses to queries concerning benefits of working on watershed analysis.

STATEMENT OF PROBLEM AND PURPOSE

This study seeks to identify and analyze the enabling and disabling factors Forest Service teams face when conducting interdisciplinary watershed analysis (watershed analysis). The study also attempts to determine what benefits resource specialists as well as the Forest Service have gained in undertaking watershed analysis.

The following questions were used to identify these issues: What factors enable or disable interdisciplinary analysis by Forest Service watershed analysis teams? Has watershed analysis been a beneficial experience for specialists and for the Forest Service? What improvements to watershed analysis are warranted?

RESULTS

Enabling Interdisciplinary Watershed Analysis: Internal Conditions

Enabling factors described by teams were predominantly internal condition factors. Enabling internal conditions are categorized as techniques, team dynamics or personality issues (Table 1).

Techniques. When asked to define techniques that enabled interdisciplinary work, all sixteen teams identified use of geographic information systems (GIS). GIS was identified as an invaluable tool for enabling everyone to access similar data. A team leader said, "Seeing maps after being in the field together really helps things click into place. This is where we had the most interdisciplinary watershed analysis." Many team members identified the visual nature of GIS as being integral to facilitating communication between specialists.

A hydrologist found that "field trips are the best by far." Field trips enabled teams to see conditions of the watershed together and point out interconnections between disciplines. Like the enabling effects of GIS, the predominant response indicated that field trips enabled interdisciplinary analysis because of their visual nature. Written reports and data presentations are not very stimulating, whereas being in the field "makes functions and processes very real" (hydrologist).

Two teams said that multi-day camping trips in the watershed enabled teams to thoroughly discuss each resource's perspective, bond together as a team and learn about the disciplinary worldview that each specialist represents. Like field trips, these trips

Table 1. Internal Condition Factors Enabling Interdisciplinary Watershed Analysis.

Category	Enabling Factor	Number of Group Responses (n=16)	Percent
Techniques	Use of GIS	16	100%
	Field trips	16	100%
	ID Team Meetings	13	81%
	Innovative techniques	12	75%
	Informal meetings	8	50%
	Read other disciplinary reports	4	25%
	Dedicated team	2	13%
	Work weeks (dedicated time)	1	6%
Team Dynamics	Mutual respect	16	100%
	Good communication	8	50%
	Consistent group membership	3	19%
	Team building exercises	3	19%
	Good team buy-in to process	2	13%
	Team cohesiveness	2	13%
Personality Issues	Good team leader	13	81%
	Team player	7	44%
	One-on-One Interaction	6	38%
	Sense of humor	6	38%
	Curiosity	4	25%
	Interest in project	2	13%

enabled teams to discuss disciplinary perspectives more readily. Specialists were able to point out hypotheses or findings visually.

Twelve teams mentioned innovative approaches that enabled interdisciplinarity. Six teams employed team teaching where specialists teach the team about the watershed from their perspective. Team members liked this technique for its tendency to force people to articulate their disciplinary worldview. Good discussions usually followed team teaching presentations.

Another team used flowcharts to produce visual representations of cause and effect in a watershed. Exhaustive flowcharts of watershed issues and related functions and processes enabled all members to participate. This same team developed hypotheses about the watershed and prioritized data refinement around these hypotheses. Team members had a harder time using these techniques, the team leader noted. "Overall, though, I think we achieved a higher level of synthesis having done them." One team performed team editing using a laptop computer and overhead projector. Specialists' reports were projected and group critique ensued. This type of direct critique was difficult for some team members to handle, but after doing it on a couple of watershed analyses, the team got accustomed to it and began to "understand each other [as specialists] a little better" (hydrologist). Two teams identified the importance of shifting the emphasis from specialists saying, for example, "bald eagles are a wildlife concern to saying bald eagles are a team concern" (team leader). This shift changed the emphasis to team thinking rather than specialist thinking.

One group pointed out the importance of trying to begin interdisciplinary analysis early and not wait until the synthesis step (step five of six). "Strictly following the steps kind of inhibits integration," a wildlife biologist noted. Reports written with other resource concerns in mind were easier to read and easier to integrate in the end. One specialist noted, however, that too much concern for other resources produced reports that were repetitive.

Another group tried to look at concepts of underlying functions in the watershed (e.g. hydrologic functions). Then they discussed those concepts and came to a common understanding of them. The team leader felt that this approach created a team that was "nothing if not interdisciplinary!" An ecologist added to this discussion: "by focusing on how the system works, we achieved more integrated thinking and analysis, but team members are not researchers and are not practiced at thinking about how the system works -- we're practiced at thinking about how to do good management and minimize environmental impacts."

Two teams had experiences with cross training of specialists. A fish biologist, for example, was assigned to write the human uses section. This practice enabled specialists to see more clearly the disciplinary orientation of other specialists. Also, team members learned much more about that material than from lecture-style data presentations.

A last innovative technique employed land stratification techniques to better enable interdisciplinary analysis. One team used land units, while another worked at the sub-watershed level. Each was satisfied with the ability of most people on the team to see most of the issues at this scale.

Almost all groups held interdisciplinary team meetings and many discussed the importance of informal meetings. Some specialists cited casual interaction as the time when "real" integration takes place. A hydrologist said, "...this watershed analysis was more informal than past watershed analyses. What I mean is that it [interdisciplinary analysis] didn't happen as much in meetings as it did in casual conversations outside meetings. Interaction around the office is what did it for me." Six respondents discussed the frequency with which interdisciplinary analysis was made through one-on-one discussions between resource specialists.

Four groups discussed the importance of reading other disciplinary reports consistently and thoroughly. "It's critical to make sure you read everyone else's work," one wildlife biologist said. In most cases specialists simply didn't have time to read reports. One team leader insisted that specialists read before coming to meetings. "The meetings are unproductive without people reading the reports." Interdisciplinary analysis was enhanced when specialists knew what other team members had to say.

Two dedicated teams advanced the dedicated team as the preferred method for interdisciplinary work. Both of these teams operated out of Supervisor's Offices (Forest-level headquarters). Dedicated teams offer a number of enabling factors for interdisciplinary work. First, team stability is high and members have an extended opportunity to get to know each other personally and professionally. Team members also cited the continuity of team membership in dedicated teams as an advantage. One of the three dedicated teams interviewed was dedicated in name only, and members grew increasingly frustrated with non-watershed analysis workloads that would not allow for good interdisciplinary analysis. One team cited "dedicated time" as an enabling factor. "Dedicated time without interruptions for synthesis is extremely valuable" (hydrologist).

<u>Team Dynamics.</u> Mutual respect and good communication were overwhelmingly identified by interviewees as enabling factors. In sum, results categorized as team dynamics demonstrate that the above mentioned techniques are only good if people (1) exchange information, (2) learn how to communicate across disciplines and (3) integrate others' information and perspectives into their own thinking about an issue or problem.

"First and foremost, the team members respected each other . . . They [the watershed analysis team] had an existing professional relationship" (district ranger). Respondents indicated that only rarely did team members not treat each other with professional respect and that those incidents were usually when specialists took exception to critiques of their writing. Most specialists responded that teams behaved as professionals and respected each other as "experts" in their respective fields. This atmosphere enabled dialogue, criticism and learning to occur. Respondents did not deny that conflicts existed. "People butt heads all the time," one fish biologist noted. Disagreements remained "professional" however, and differences were resolved in one-on-one discussions.

Teams enjoyed the climate that this respect fostered. Compared to the advocacy-style format of National Environmental Protection Act environmental assessments, people rarely "got nasty" or "pulled rank." This climate enabled people who traditionally hadn't spoken much to each other to work together. "Teamwork is qualitatively different than environmental assessments. Less pressure, more fun, more `academic'" (geologist). "Learning is stressed over the product," a silviculturist added.

Interdisciplinary analysis required good communication as well. Four means of achieving this were identified by six groups. One team fostered increased understanding of specialist reports by replying "So what?" to information presented at meetings. Each specialist thus became adept at explaining the relevance of their results to the central issues of the analysis. This approach was closely echoed by another team's reliance on "logic backtracking." On this team, specialists always explained how they arrived at a given characterization, judgment or conclusion. This practice enabled other team members to gain further insights into disciplinary methodology. A third factor (noted by two teams) involved the ability of specialists to get other team members interested in what they have to say. A fish biologist's real interest in his or her subject "gained a more captive audience at an interdisciplinary team meeting than someone just going through the motions" (fire/fuels specialist).

Presentation of the highlights of one's results in meetings also enabled better interdisciplinary analysis. Team members noted that specialists were "totally overloaded with information" and needed summarized information. This need for efficient information exchange was related to the limited time specialists usually had available for watershed analysis. The ability to engage with other specialists was reduced when too much information was presented in lecture-style presentations. Presentation of visual material (slides, overheads and drawings) with a short narrative of key findings engaged team members in discussion.

Another important team dynamic was identified as consistent team membership. Three respondents cited the consistency of team membership as essential to producing well-integrated watershed analyses. Achieving a comfort level with each other, adjusting to each others' working styles, and understanding individuals' jargon were all cited as benefits of having consistent team membership. A member of a dedicated team stressed that after three years of working together, team members could read each other's reports and understand them immediately. This reduced the amount of time spent in discussions about terminology, for instance. Team consistency also promoted greater effort on the part of team members. "One-time members do not necessarily give one hundred percent," one team leader noted. The same team leader said that keeping the same personnel together also fostered a better work ethic (fewer absences from meetings, more active participation).

Three groups mentioned the importance of teamwork training. The teamwork required by watershed analysis is different than that required by other teams specialists have participated in. Specialists must think "as a team, rather than as specialists," one silviculturist said. Training focused on not thinking exclusively as an individual but rather as a team member were helpful for these three teams. A fish biologist said that watershed analysis requires specialists to act like generalists. To accomplish this, specialists need additional training. Another specialist noted that preliminary training of the team in methods of teamwork benefited the team by allowing members to work out superficial and semantic differences before the watershed analysis had begun.

Two groups discussed the importance of team cohesiveness. A watershed analysis team that cooperated closely produced good interdisciplinary analysis, a vegetation specialist noted. A much less cohesive team was characterized by team members who skipped meetings, turned in reports late, and had less buy in to the watershed analysis, the same vegetation specialist added. "We had a good time together as a team, going on field trips and camping trips. We had potluck meetings and a barbecue" (team leader). The primary advantage of this, the team leader related, was that specialists took pride in the watershed analysis.

Personality Issues. Next to team dynamics, the right mix of personalities was another widely discussed enabling factor. A geologist suggested that groups "spend a little more time at the beginning for getting past personality conflicts. Clarify goals, expectations, and commitment level: these things allow the watershed analysis to proceed more smoothly."

Interview discussions revolved around two primary areas: the importance of the team leader and desirable personal qualities for team members. Fourteen teams discussed the importance of the team leader. A wide range of duties and personal characteristics were described:

1) Duties the team leader must take on: The team leader must set the tone for mutual respect and provide a positive atmosphere for team members to work in. Setting of realistic deadlines, establishment of ground rules, and identification of the level of detail desired from specialists should be addressed by the leader early in the watershed analysis. One team cited their leader's ability to explain the watershed analysis process to new team members as an essential key to their success. Another team noted that the

leader had the responsibility of translating the expectations built into each step and management's objectives for the analysis.

The team leader also acts to eliminate reliance on jargon and to ensure that all members are clear on each specialists' contribution (one team). A good team leader is fluent in more than one discipline and can see how to best integrate the watershed analysis. One team praised their leader for emphasizing interdisciplinary analysis throughout the watershed analysis. This team leader had specialists formulate hypotheses about the watershed and collect data to support (or disprove) those hypotheses. This exercise forced specialists to call upon each other for supplementary evidence (the wildlife biologist consulted heavily with a fire/fuels specialist and ethnohistorian, for example). Lastly, one group noted that having good ties with supervisors and the ranger enabled the team leader to understand specialists' workloads and priorities and plan the watershed analysis accordingly.

2) Personal characteristics of the team leader: The primary qualities team leaders have for promoting interdisciplinary work are "people skills." One team leader declared, "Leading an interdisciplinary team is like herding a bunch of cats!" The variety of disciplines, ages, genders, ranks and resource management orientations (to name but a few variables) make leadership a sometimes daunting prospect. Teams cited the following desirable characteristics in a team leader: (1) strong, but not domineering, (2) ability to get shy people involved, (3) committed to the project, (4) facilitation and diplomacy skills in conflicts and (5) extremely patient. One team noted the effectiveness of having a newcomer as the team leader: "On a later watershed analysis team, the team leader was fairly new and didn't know all the jargon people used. This actually helped in that she made specialists explain everything they were talking about" (wildlife biologist).

Respondents also discussed qualities team members should have. The primary quality was the ability to work well with others. As a wildlife biologist put it, "Probably the most important skill anyone can bring to the team is the ability to work well with others. If you can't, eventually you'll drop out and slow down the entire process in the meantime." Additionally, team members should have a sense of humor, be interested in the project, be curious, and desire to learn more about other fields.

Enabling Interdisci l' arv Watershed Analysis: External Conditions

Few descriptions of enabling external conditions were elicited during the interviews. Preliminary survey data contained some additional references to enabling factors in this category. Enabling external conditions are categorized as logistics, resources and institutional issues (Table 2).

Institutional Issues. Watershed analysis is not a decision-making process requiring National Environmental Protection Act documentation as are environmental assessments. Specialists routinely participate in interdisciplinary teams on environmental assessments. The difference between these two processes relative to interdisciplinary analysis is dramatic according to respondents. Environmental assessments lead to a decision about a proposed land management activity. Specialists advocate for "their resource" on environmental assessment teams and conflict is frequent. National Environmental Protection Act "interdisciplinary" teams are interdisciplinary in name only, many respondents claimed.

Many teams said that watershed analysis was not such an arena. The prospects for working interdisciplinarily were much higher in the watershed analysis setting. The watershed analysis atmosphere is more relaxed and research oriented, both enabling factors for knowledge sharing and dialogue.

Table 2. External Condition Factors Enabling Interdisciplinary Watershed Analysis.

Category	Enabling Factor	Number of Group Responses (n=16)	Percent
Logistics	Shared office space	3	19%
Resources	Proper staffing	3	19%
	Dedicated time	2	13%
Institutional Issues	Non-NEPA document	16	100%
	Line support	12	75%

The Northwest Forest Plan's requirement that watershed analysis be completed before projects are completed in key watershed does add a time constraint to watershed analysis, two teams noted.

One team said that good line officer support for the watershed analysis process encouraged the team to work harder, knowing that "the chances for implementation of our recommendations was higher" (fire/fuels). A geologist put it this way: "This must be a challenging, enjoyable process, not a paper exercise!"

Resources and Logistics. Three teams discussed the importance of proper staffing. "Choose good team players to do it [watershed analysis]. It's best to have the right person for the right job" (team leader). Three teams stressed the importance of having shared or closely proximate office space. This made for much more frequent communication between specialists. Specialists located off the district, or Forest-level specialists were "out of the loop" and missed the hallway and break room discussions. A fire/fuels specialist detailed the importance of shared office space: "You're not working in isolation, you can bounce ideas off each other all the time, and writing is a lot easier, because you can ask for help."

Disabling Interdisciplinary Watershed Analysis: Internal Conditions

Fewer internal disabling factors were reported than enabling factors. Disabling external conditions are categorized as techniques, team dynamics and personality issues (Table 3).

Techniques. One team discussed the difficulty of starting from scratch with every watershed analysis. This included having new team members and determining an appropriate methodology for completing the watershed analysis. The team had yet to find

Table 3. Internal Condition Factors Disabling Interdisciplinary Watershed Analysis.

Category	**Disabling Factor**	**Number of Group Responses (n=16)**	**Percent**
Techniques	Poor time management	7	44%
	Lack of model to follow	1	6%
Team Dynamics	Disciplinary difficulties	9	56%
	Lack of team buy-in	6	38%
	Employee mobility, team transience	4	25%
Personality Issues	Disabling personalities	8	50%

an efficient method for interdisciplinary analysis and for completing the watershed analysis in a timely manner. Teams also were initially unclear about exactly what constituted interdisciplinary analysis. All expressed confusion about what exactly interdisciplinary analysis was.

Another issue addressed was time management (seven teams). Teams frequently found themselves in the position of having spent too much time on steps one through four and strapped for time at the critical steps five and six. Consequently, interdisciplinary analysis failed to happen. Much of this time budgeting problem arose from team members' discomfort with using available data, as the watershed analysis guidelines mandate. "The synthesis step was the one that we always spent too little time on. We were always pressed for time by then and always regretted that we didn't have time to do as much synthesis as we felt was appropriate and desirable" (team leader).

A last issue concerned the methodological practice of writing separate reports. A soil scientist noted that "separate reports can lead you to do the best for your report and ignore the rest."

Team dynamics. Watershed analysis teams had upwards of ten core team members (representing up to ten different disciplines). Extended teams may have up to thirty members (representing up to twenty disciplines). With so many disciplines represented several difficulties arose. Teams identified the following disabling factors: divergent orientations (land management and scientific) of specialists (three responses), different learning styles (one response), conceptual orientation of specialists that makes different people work better at different scales (one response) and the inability of terrestrial and aquatic interests to integrate (two responses).

Employee mobility and team transience were seen as disabling of interdisciplinary analysis. While many districts have attempted to maintain a consistent core team, team leaders may change, core team members may have higher priorities at any given time, employees take annual leave, team members accept assignments to other projects and so on. The range of variability in team membership is as high as the number of variables associated with selecting a team. For example, when there is only one fire/fuels management person on the district, that person will be on the team, regardless of whether he or she is a good team player, is open to learning new methods, or is a good listener.

The issue of lack of team interest in the watershed analysis process was identified by six teams. "My perception is that the majority of the participants aren't buying into the process and therefore don't really interact as a team" (fish biologist). While a single individual rarely stalled the watershed analysis process, one team leader detailed how a clique of recreation and roads specialists (who didn't buy in to the watershed analysis process) slowed a watershed analysis to a crawl and effectively turned off a lot of team members from team interaction. Without buy in to common goals, integration was up to the editor, who in this case was also the team leader. The team leader's enthusiasm for the next watershed analysis was considerably lower.

A disciplinary difficulty involved poor communication. The potential for good interdisciplinary analysis is drastically reduced when team members cannot communicate effectively with others. One team leader's great frustration with a team of large egos and poor communicators said, "I think the concept of interdisciplinary integration is a fantasy . . . Individuals vary in their abilities to integrate with others."

Personality Issues. Eight groups identified three disabling factors classified as disabling personalities. First, egos got in the way of interdisciplinary work. Mostly, ego was an issue in the writing stages. Specialists can "get really upset when their work is critiqued," one team leader said. The separate report style of the current watershed analysis guidelines is responsible to some extent for the specialists' perception that "their" report should maintain its individual identity. The past practices of National Environmental Protection Act work also contribute to this situation because specialists are accustomed to defending their written reports, sometimes fiercely.

A second personality problem involves "slackers." One team leader said that "there's one on every team." These individuals tend to be late with reports, do not consistently attend meetings, and show a lack of interest in watershed analysis. These individuals frequently had supervisors who hadn't bought into the watershed analysis process. This same team leader acknowledged that if the subject area represented by a "slacker" is critical to the success of the watershed analysis, their presence (or absence) can have a derailing effect.

Finally, one team discussed the issue of disciplinary scope. Some specialists operate well looking at the broad scale of the watershed, while others are unable to do so effectively. Integrating these two scales can be difficult, especially when presenting data.

Disabling_Interdisciplinary Watershed Analysis: External Conditions

The majority of responses in the disabling category were characterized as external conditions. Disabling external conditions were categorized as logistics, resources, and institutional issues (Table 4). An additional category was created here to address document issues. Without any direct querying, eight teams discussed disabling issues that originated during the production of the finished watershed analysis product.

Logistics. Three interagency watershed analysis teams were interviewed (BLM and Forest Service). Unfortunately, none could assemble the entire interagency team for the group interview, a hint at the logistical difficulties interagency teams face when conducting a watershed analysis. Interagency teams present two primary logistical difficulties. The primary difficulty is data compatibility. Everything from e-mail to

Table 4. External Condition Factors Disabling Interdisciplinary Watershed Analysis.

Category	**Disabling Factor**	**Number of Group Responses (n=16)**	**Percent**
Logistics	Interagency difficulty	3	19%
Resources	Data difficulties	16	100%
	Inadequate time	15	94%
	Inadequate budget	15	94%
	Competing workloads	15	94%
	Poor team composition	1	6%
Institutional Issues	Management difficulties	14	88%
	Past practices	10	63%
	Inadequate feedback	5	31%
	Interagency difficulties	5	31%
	Employee mobility, team transience	4	25%
	Determining riparian reserves	2	13%
	Lack of ID training	1	6%
Document Issues	Disciplinary structure	7	44%
	Multiple audiences	4	25%
	Writing/editing limitations	3	19%

vegetation classification schemes are different and create time-consuming difficulties for watershed analysis teams. The second difficulty was in scheduling meetings and work sessions between agency personnel.

Another logistical disabling factor was identified as a poor physical working environment. A team leader described this situation as: "Not having a room designated as the watershed analysis project room where we could leave maps up and flipcharts and flowcharts on the wall and just let the ideas sink in and allow the mind to do its work in its mysterious way."

Resources. Resource issues were the most commonly cited disabling factors in the entire study. All teams identified difficulty working with existing or new data, nearly all identified inadequate time, budget and competing workloads (fifteen out of sixteen). These resources are external in origin and in relationship to team members. A great deal of frustration was shown when discussing these issues. Team members, indeed whole teams, burned out most frequently due to these conditions.

Every team had some experience where interdisciplinary analysis suffered from poor timing of GIS products. Most frequently, products came in too late for the team to successfully integrate them into reports or into the finished document. A primary reason for this failure was the lack of planning to coordinate GIS products for timely production. Instead, GIS products are requested as a watershed analysis proceeds. Additionally, poor integration of GIS specialists into watershed analysis teams decreases the quality of products.

One team discussed the trap of spending too much time refining or developing data, then not having enough time to integrate that data. Two other groups discussed the inadequacy of "available" data. Some noted that data were severely outdated. Specialists felt uncomfortable making generalizations about a watershed with poor data.

Next, all but one team agreed that the limiting factor to interdisciplinary analysis was time and budget available. "Watershed analysis is an intellectual challenge that leads to growth in knowledge and skills. We got there by discussion and having time to do so. But time is the limiting factor here. You need time to do this" (fire/fuels specialist). Just as time was the enabling factor for this specialists' team, limited time effectively halted interdisciplinary efforts. The problem of inadequate time was especially acute for some teams. One district team related the progressive reduction in watershed analysis budgets, culminating in allocation of only eighteen days for completion of their most recent watershed analysis. Unreasonable time frames such as this can have demoralizing effects on team members, as this team leader stated. They also equated this budget reduction as a vote of "no-support" for watershed analysis process from the district and the region. Team members were unwilling to put forward the extra effort interdisciplinary work requires in this situation.

Inadequate time has a two main consequences, as various teams discussed. Specialists do not have time to read other reports and discuss them fully in team meetings. Limited possibilities exist for blocks of time to be set aside to engage in the time-consuming process of integrating and analyzing data.

A related concern (fifteen responses) was the competing workloads specialists carry when performing a watershed analysis. A silviculturist described a common situation where "we would be on a roll and then something would come up that was a higher priority to work on." Watershed analysis was the first thing to be dropped when a crisis came up. Even the most supportive line officers were caught in this situation. Team members wind up "stealing time" here and there simply to complete their portion of the watershed analysis. Many specialists described how they frequently don't even have official time allocated to work on watershed analysis.

Even a "dedicated team" expressed the following frustration: "Although this was supposed to be a dedicated team, team members were always running into other commitments and having to steal time to work on the watershed analysis. People would show up to meetings without doing the required work. They just did not have the time or resources to commit. This was the big problem that affected every aspect of the watershed analysis process" (team leader). An entomologist called this the "full plate syndrome." "This [watershed analysis] was an add on job. Nothing was taken off the plates of the participants" (entomologist).

A minor concern (one team) involved lack of resources for adequate staffing of the watershed analysis team. Missing resources were "covered" by specialists with their hands already full, and in one case one specialist covered three resources.

Institutional Issues. The relationship of watershed analysis to management is an evolving one. Widespread confusion about this relationship was noted by respondents (ten responses). There is no mandate to utilize watershed analysis results and watershed planning is still evolving. Management, in many cases, sees watershed analysis simply as another hoop to be jumped through before projects can be carried out. Thus, team members repeatedly noted that they were encouraged simply to complete watershed analysis as efficiently as possible. Under this arrangement teams were hardly likely to want to put a great deal of effort into the process. Surprisingly, many respondents noted that team members have still bought into the watershed analysis process, even when management has not. Resource specialists predominantly see watershed analysis as an opportunity to "do good things for the resource," as a silviculturist pointed out.

Many teams added that line officers rarely attended meetings and had low involvement overall. A fundamental consequence of this was that managers did not understand the complexity of interdisciplinary work required to produce a watershed analysis. For one team this tension between management's desire to complete the watershed analysis quickly and specialists' desire to do a good job (which can take longer, especially with competing workloads) came to a head when the team leader had to plead with line officers for specialists' time. This created stress for the team leader and the team.

Respondents also expressed frustration with what a fisheries biologist called "the lack of any visible effect of the watershed analysis on project planning in the watershed." This "disconnect" between the watershed analysis and project planning in the watershed was frustrating for many respondents. Knowing that implementation of watershed analysis recommendations would not occur discouraged team members from putting any extra effort into the watershed analysis.

Short timelines reduced the amount of time for interdisciplinary analysis. Teams were unable to meet as frequently as desired, one team leader noted. A fish biologist said that a watershed analysis in which the team had more time to explore the issues they identified had more interdisciplinary analysis. "The first ones [watershed analyses] were better, as we had the luxury of exploring issues as they unfolded. Later ones are more focused on meeting short deadlines" (geologist).

Another difficulty with management arose when two teams were instructed to focus on a very limited number of issues in a watershed. This effectively precluded an examination broad enough to allow objective identification and prioritization of issues and process interactions. "It was difficult to keep management perspectives out for a purely objective look at the watershed" (team leader).

An additional institutional issue perceived as a barrier by teams was the influence of past "interdisciplinary practices." "When budgets and especially time are limiting, it's easy to fall back on 'how we've done it before,' instead of promoting creative, innovative, exploratory analysis" (hydrologist). "How we've done it before" generally consists of compilation of individual reports. Relatedly, three teams said that it will be a long time before the functionalism of the Forest Service is fully supplanted by interdisciplinary ecosystem management. For the purposes of individual watershed analyses, a silviculturist had this to say: "Get out of the box of splitting things by discipline. But this effort would take more time which we never seem to have."

Another institutional issue has to do with feedback and review of watershed analyses. Comments included: "There is no review," "We need substance-specific feedback," and "Rangers usually just accept the finished product because it's finished." Respondents expressed frustration in not knowing how good their completed products were. Since implementation of watershed analysis into planning is scattered at best, teams expressed feelings of "being isolated" and "in a vacuum" when attempting to define how well they did. Indeed, when queried about what level of interdisciplinary analysis they achieved, most were unsure as to what constituted good interdisciplinary analysis. One team was critiqued for not having enough interdisciplinary analysis. Yet, the reviewers had no models of what good interdisciplinary analysis looked like to show the team. Another team reported that early watershed analysis reviews were contradictory, with some reviewers satisfied with the level of interdisciplinary analysis while others insisted no such analysis was present. One respondent added that another source of feedback does occur in the form of outside appeals of project decisions.

Five teams also identified interagency difficulties. One team related how unequal commitments by agencies disabled interdisciplinary analysis. Three teams identified differing agency cultures, differing land management philosophies and proprietary jargon as prohibitive to interdisciplinary work. Overcoming those obstacles was possible, but it took more time than was available.

Two teams functioned poorly when they tackled the controversial issue of riparian reserve widths. So many people weighed in on the team's judgments, "it became a total political football," a fisheries biologist noted. The issue remained unresolved and the watershed analysis "couldn't have been over soon enough" (fisheries biologist). The team got so caught up in the power struggle taking place, they lost focus on the issues in the watershed analysis.

A last response in this category cited a lack of interdisciplinary training for "this new generation of interdisciplinary teams" (fisheries biologist). Specialists are not always clear on how to go about achieving interdisciplinary analysis, and lack of training disables interdisciplinary analysis.

Document Issues. Seven groups described the document structure as limiting to interdisciplinary work. "It's easier (and we are used to) organizing the document by discipline, so that tends to limit interdisciplinary analysis" (silviculturist). Several teams said they were accustomed to doing National Environmental Protection Act documents, so it was easier to follow that model, especially when time was factor.

A team leader struggled with this issue extensively. "The document is hard to make interdisciplinary, how do we organize it to be interdisciplinary? It's really hard to get around presenting it in a disciplinary fashion." When the team presented a more holistic document, line officers criticized it for having lack of structure. Since that time, the team leader has discovered a "happy medium" in using issues as the chapters and integrating analysis in each chapter.

Respondents also noted the difficulty of having multiple audiences for the finished watershed analysis product. Four teams acknowledged a sense of confusion over who exactly the document was to be written for. Theoretically, the finished watershed analysis is for resource specialists, management and the public. Writing for all three of these audiences proved to be a barrier for teams, as these three audiences required different levels of detail. For a wildlife biologist, "the trouble was in translating discussions to a document that the public can understand."

Three teams acknowledged difficulty in transferring the results of interdisciplinary work to the documents. Mostly, this had to do with the inability of team members and writer/editors to record important syntheses reached during team meetings. Usually, this process was the responsibility of the writer/editor. One team's watershed analysis suffered from having an outside writer/editor without good ties to the district. The writer/editor did not have a working knowledge of the watershed and slowed the team's progress. Another explained that simply producing the watershed analysis documents became a time-consuming effort itself. The time required for document production cut into time available for analysis work. Three teams discussed the disabling factor of choosing words, where teams spent a lot of time arguing over word choices in the editing process.

Benefits of Interdisciplinary Watershed Analysis

When respondents were queried about whether or not they personally benefited from the interdisciplinary aspect of watershed analysis teams, they overwhelmingly answered affirmatively. Respondents expressed a sense of personal satisfaction in expanding their vision of resource management from a narrow disciplinary focus to a much broader one that included understanding of other resources. Respondents also talked about benefits accrued for the Forest Service. Theses two categories are not fully exclusive, however. Personal benefits are interlaced with institutional benefits (Table 5).

Personal Benefits. Respondents felt that they had developed more interdisciplinary skills (thirteen teams). A fish biologist, for instance, benefited from interactions with a geomorphologist: "When I go out to do restoration work, I see more

Table 5. Benefits of Interdisciplinary Watershed Analysis.

Category	**Description**	**Number of Individual Responses (n=16)**	**Percent**
Personal	Professional skills enhancement	13	81%
	Knowledge enhancement	10	63%
	Gained ecosystem perspective	9	56%
	Improved interpersonal skills	5	31%
	Enjoyment	3	19%
Forest Service Benefits	Better project planning	9	56%
	Better overall management	8	50%
	Increased communication	8	50%
	Increased knowledge base	4	25%
	Ecosystem management	3	19%
	Improved interagency relationships	2	13%

than available habitat. I'm beginning to see where better opportunities exist for restoration." A geologist added, "watershed analysis gave me the opportunity to expand my skills in landscape-level analysis, particularly around aquatic/geologic interactions."

Ten teams discussed how watershed analysis enabled specialists to enhance their knowledge of the watershed. A team leader related how watershed analysis enabled team members to look at current literature and "put ideas and concepts from the ecological literature together with a specific landscape."

Nine teams discussed the personal benefit of engaging with an ecosystem management process. Seven teams said that watershed analysis was the most "ecosystem management" oriented activity taking place on the forest. Teams agreed that watershed analysis represented a significant change for them in perception of the land. One wildlife biologist said, "We're ruined as resource specialists! We're resource generalists now." Another wildlife biologist envisioned having a "titleless" job in the future where all resource specialists were ecosystem specialists.

Personal satisfaction was a direct result of this engagement. Three groups noted that watershed analysis was highly enjoyable in this respect. The ability to see the big picture was how most described this benefit. "Until now, we've rarely been able to look at the big picture. Watershed analysis is an excellent opportunity to do so" (fish biologist). Production of watershed analyses, though, was noted as a limiting factor to this benefit: "The first four were enjoyable, then burnout occurred and I became bored with producing the same products and working with the same people" (geologist).

Another benefit teams recognized was enhanced interpersonal skills (five teams). One specialist said, "people are learning how to work together better" (team leader). Team members also engaged with specialists they had little interaction with to date. "[Watershed analysis] gives you another perspective. Your blinders are not so tight against your head. This makes it easier to work on a team down the line" (wildlife biologist).

Forest Service Benefits. "Watershed analysis is the best ecological work that's being done on the forest. It is the most thoughtful, most useful work we do. Not so coarse scale that it does not say anything new (as the late successional reserve assessments tend to do) or so small and production oriented that it is just putting out widgets (like the environmental assessments tend to be). It best integrates watershed and terrestrial processes" (team leader). Nine groups responded that watershed analysis leads to better project planning. There was ambivalence in these responses, however, as many teams stated that this belief was largely speculative and not yet fully realized.

Developing synthesized knowledge through watershed analysis was identified as the ultimate benefit to Forest Service land management because it would lead to better project planning. One team said that the discoveries of a watershed analysis were usually interconnections that had been unknown or wrongly identified before and had led to poor management decisions. Four teams identified a related benefit: watershed analysis developed a "larger knowledge base overall for that particular watershed and for approaching future problems and projects" (geomorphologist/soil scientist).

Eight groups cited increased communication between departments as a benefit for the Forest Service. "Watershed analysis more or less forced us to get together," one cultural heritage specialist stated. One team said that watershed analysis team interaction benefited the entire district by allowing people to get beyond the superficial assumptions specialists tend to make about each other. "Everyone has a greater appreciation for others' resources," said one forester.

Finally, three teams discussed the idea that watershed analysis represented the first "on-the-ground" implementation of ecosystem management for district personnel. A district ranger said simply, "The watershed analysis process is moving us away from commodity production and toward ecosystem management."

DISCUSSION

The present study uncovered specific enabling and disabling factors to interdisciplinary watershed analysis (watershed analysis). These factors show that watershed analysis teams faced considerable challenges to interdisciplinary analysis. The findings also reveal solutions watershed analysis teams found while working to complete interdisciplinary analysis. The study also discovered some of the benefits the specialists and the Forest Service gained by conducting watershed analysis.

Teams predominantly reported internal condition-type enabling factors and external condition-type disabling factors. The prominence of enabling internal condition factors and external disabling factors suggests that interdisciplinary analysis has come about through individual and team effort in spite of obstacles external to the team.

It should be noted, though, that the exploratory and qualitative nature of this research prohibits extrapolation or generalization of findings. The following discussion analyzes the principal factors discovered during the study.

Enabling Interdisciplinary Watershed Analysis

Techniques. The most prominent enabling techniques identified were use of geographic information systems (GIS) products (maps, overlays and models) and field trips. These techniques enable interdisciplinary analysis by allowing team members to ascertain resource interactions (between soils and vegetation, for example). The visual nature of GIS products and field trips enable team members to avoid two major impediments to interdisciplinary analysis: disciplinary jargon and text-based information (Luszki 1958, Regier 1978). GIS products also enable interdisciplinary analysis by allowing specialists to clarify disciplinary concepts to each other. Instead of relying exclusively on the language of silviculture, for example, a silviculturist can point to features on a GIS map to clarify silvicultural concepts to a fish biologist.

Field trips add a another real dimension to the analysis. Forest Service district resource specialists are field personnel. Many have an intimate knowledge of the landscape and can best communicate their ideas about a watershed to other specialists in the field. Field trips enable specialists to interactively analyze current resource conditions and speculate about future conditions. On a field trip, a geologist can point out geologic foundational features, a forester can speculate about which harvest techniques might be appropriate given the geology, a fish biologist can develop hypotheses about how habitat is affected by both geology and silvicultural practices and a cultural resources specialist can describe past management practices. The essential feature of this technique is that specialists interact and communicate to each other about the underlying functions and process that will dictate future management practices.

Team Dynamics. Mutual respect among specialists was the most prominent finding in this category. This finding corroborates with a key enabling factor identified in the literature on interdisciplinary analysis and watershed analysis (Luszki 1958, Russell 1982b, Klein 1990, Reid 1996). In order for interdisciplinary analysis to take place, team members need to learn from each other. This requires that specialists respect each other's opinions and knowledge. Mutual respect creates a forum where ideas can be shared and critiqued without hard feelings. Such a forum takes time to develop for most teams. Once created, though, interdisciplinary analysis becomes easier.

Good communication between specialists also enables interdisciplinary analysis. Specialists need to communicate to each other ideas, concerns and information. For some disciplines, this means communicating with unfamiliar resource specialists. Good communication enables discussion in team meetings, informal meetings and in specialist reports. Breaking down disciplinary jargon involves talking with each other and asking questions when concepts or ideas are unclear. Like the development of mutual respect, good communication between specialists takes time and effort.

Personality Issues. Interdisciplinary analysis ultimately relies upon disciplinary specialists for its completion (Klein 1990). Forest Service watershed analysis team specialists in this study were predominantly scientists trained in natural resource management fields. While many had experience in multi-disciplinary teams prior to watershed analysis, none had participated in an undertaking such as watershed analysis which prioritizes interdisciplinary analysis of an entire watershed. Team members identified the personality of the team leader as key to accomplishing interdisciplinary analysis. Interdisciplinary analysis requires a team leader who can get specialists to communicate with each other, explain the watershed analysis process to new members, and interact with management. The team leader must also establish ground rules of mutual respect and discuss the level of detail desired from specialists.

This importance assigned to the team leader suggests that teams are struggling to find means to accomplish interdisciplinary analysis. A team leader who has a good understanding of interdisciplinary analysis is essential for leading inexperienced teams.

Personalities of the team members were specified as well. Interdisciplinary analysis flourishes when team members can get along well with others, have a sense of humor, are scientifically curious and have an interest in the project (Luszki 1958, McCorcle 1982).

External factors. Watershed analysis does not require teams to produce decisions about land management. Teams identified this factor as enabling them to enjoy a more academic atmosphere. In this atmosphere, specialists felt free to pursue avenues of inquiry they would not pursue if the finished product was a formal land management decision. This orientation corresponds most closely to successful models of interdisciplinary analysis in the literature (Klein 1990).

Disabling Interdisciplinary Watershed Analysis

Internal Conditions. Few internal condition disabling techniques were discussed by teams suggesting that teams found interdisciplinary analysis largely disabled by factors external to the team. Poor time management, cited by several teams, suggests again that teams are grappling with a new process where procedures and timelines are not well known. Teams spend too much time detailing current and reference conditions and not enough on synthesis and interpretation where teams feel most comfortable doing interdisciplinary analysis. This leads to compilations of highly detailed specialist reports, rather than highly integrated findings (Reid 1996).

Teams experienced a derailing of interdisciplinary analysis when specialists could not understand each other due to disciplinary differences. When specialists use disciplinary jargon in meetings and reports interdisciplinary analysis declines. This finding suggests that specialists are not well acclimated with disciplines other than their own.

A final finding, disabling personalities, suggests that interdisciplinary analysis is dependent on the individuals which conduct it. Interdisciplinary analysis declines when specialists do not buy in to the process, have a poor work ethic, or have large egos.

Resources. Teams identified inadequate time and budget as important resource-based disabling factors. This finding suggests that the current budget for watershed analysis is inadequate for interdisciplinary analysis to occur. Likewise, the amount of time specialists are allocated to work on watershed analysis is inadequate. Time constraints reduce the amount of time specialists can spend writing their own reports or reading others. In addition, specialists have less time for formal and informal meetings. Interdisciplinary analysis requires adequate time and budget for successful completion (Luszki 1958).

Additionally, specialists identified competing workloads as impediments to interdisciplinary analysis. The specialists experience fragmentation of focus when working on multiple projects. When non-watershed analysis related tasks must be accomplished, specialists lose the momentum of a watershed analysis. When the watershed analysis is set aside for other projects, team members spend time getting back to where they left off. This consumes time as well as specialists energy. This finding suggests interdisciplinary analysis proceeds more optimally when specialists have periods of time dedicated exclusively to work on watershed analysis.

A last major finding in this category was difficulty with missing or poorly timed GIS products or low-quality data about the watershed. Teams request GIS products as the watershed analysis proceeds, yet these products may not be delivered in a timely manner. Similarly, specialists are accustomed to needing precision data in order to justify decision-making analysis documents. The watershed analysis guidelines, however, specify that teams use only available data and make generalizations. Specialists are uncomfortable with this procedure and frequently spend time refining coarse data in order to achieve a level of precision they feel comfortable analyzing.

Institutional Issues. The major institutional complaint was lack of management support for watershed analysis. This suggests that there is not a unified attitude concerning watershed analysis in the Forest Service. Indeed, watershed analysis is an evolving procedure and is not fully integrated into Forest Service planning. Theoretically, watershed analysis is the precursor to watershed planning in the aquatic conservation strategy. In reality, watershed planning has yet to be implemented. Completed watershed analyses, therefore, have frequently been ignored. Specialists are frustrated when they feel that the work they put into the interdisciplinary analysis required by watershed analysis goes unrewarded and unfulfilled.

In a related finding, teams reported inadequate feedback and review of completed watershed analyses. Interdisciplinary teams need to have peer review of methods and products in order to be effective in present and future efforts. The lack of support from district, regional and the regional ecosystem office reduces the ability of teams to complete interdisciplinary analysis.

Current interagency watershed analysis guidelines may disable interdisciplinary analysis. This finding is explained by teams' reliance on past practices to complete watershed analysis. Teams also reported that the disciplinary structure of the finished watershed analysis document encourages multi-disciplinary work. This finding suggests two notions. Teams are caught in a transition between an older multi-disciplinary model of analysis and a newer interdisciplinary model of analysis. Teams also need a set of explicitly interdisciplinary guidelines in order to complete interdisciplinary analysis during this transition.

Benefits of Interdisciplinary Watershed Analysis

Benefits to the Forest Service included enhancement of specialists' skills and knowledge, specialists' acquisition of an ecosystem perspective, and better land management. These findings suggest that watershed analysis is an important step towards ecosystem management for the Forest Service. Ecosystem management is premised on highly educated and skilled practitioners, the ability of land managers to plan at the watershed scale, and the importance of coordinated land management (between and within agencies) (Grumbine 1994). The benefits respondents identified during the study suggest that specialists have gained skills, knowledge and experience which can help the Forest Service implement ecosystem-based management in the future.

Limitations of the Study

There were two primary limitations to this study. The first had to do with the sample of watershed analysis teams. The sample consisted of teams willing to be interviewed. Since only teams willing to be interviewed were interviewed, it is possible that teams with poor experiences with watershed analysis were unwilling to be interviewed, thus being excluded from the sample. Additionally, the sample was non-random. Combined, these factors may have skewed the study toward positive results. More importantly, caution should be used in generalizing these the findings.

The second primary limitation is that the results are self-reported. Self-reported data is subjective in nature (Babble 1992). Thus, one possible interpretation of the predominance of internal condition enabling responses and external disabling responses is that teams claimed success for themselves while finding fault in external sources.

Other limitations of this study centered on the group interview format. Internal condition results may have been more positive as team members are in the same room and thus unlikely to criticize each other. Individual interviews may have revealed more internal condition disabling factors. Also, the group format has the potential disadvantage of keeping individuals from truly speaking their mind (Babble 1992). Certain controversial topics may have been avoided in favor of more acceptable topics. A final limitation was the relatively short duration of the interviews and the fact that they were performed with each team only once.

Finally, the study may have been limited by the outsider status of the interviewer. It is well known that members of an organization do not reveal information readily to researchers from outside the organization (Fontana and Frey 1994). Although the interviewer made an attempt to ease this potential effect by becoming a Forest Service employee, the interviewer remained a relative outsider. Again, the inverted pattern of responses may have resulted from this effect. Teams may not have had a high enough comfort level with the study or the interviewer to discuss enabling external conditions or disabling internal conditions.

RECOMMENDATIONS

Interdisciplinary watershed analysis represents a search for better land management beyond what a single discipline's methods and analytic tools can uncover. Interdisciplinary watershed analysis teams are the agents of this search and are re learning about watersheds. In fact, perhaps the most significant finding of this study is that regardless of disabling factors, specialists are learning far beyond their individual resources and expanding their thinking about land management.

The utilization of interdisciplinary analysis by the Forest Service is unlikely to decrease in the future as it pursues ecosystem management. In order to fully utilize such analysis, however, the Forest Service needs to develop the organizational means to enable teams to develop interdisciplinary analysis. In addition, improved planning by teams can enable interdisciplinary analysis. The following recommendations concentrate primarily on better planning of watershed analysis and improving the watershed analysis process in the Forest Service.

Planning for Watershed Analysis

Many disabling factors identified in this study can be avoided if watershed analysis teams plan for watershed analysis. The team leader should brief team members before the watershed analysis begins. In this briefing the team leader should establish with specialists (1) clear goals for the watershed analysis, (2) the level of detail desired and (3) the intended audience of the completed watershed analysis. In addition, the team leader should conduct a pre-watershed analysis meeting where participants explain their vision of the watershed analysis and how they will participate. The team leader should carefully detail the watershed analysis process for newcomers.

Planning is also important to coordinate GIS products. GIS products will continue to be invaluable aids to interdisciplinary analysis. As such, teams should use past experiences to schedule production of these products, thus enabling their timely delivery. One fish biologist advised, "Have basic coverages ready before analysis begins or at least acknowledge that those need to be completed early in the watershed analysis and make budget allocations for that to occur."

Teams can also plan a time management scheme for the watershed analysis which prioritizes interdisciplinary analysis. Under the current guidelines, this entails leaving ample time for step five, synthesis and interpretation. Specialists spend too much time in current and reference conditions and wind up racing through step five.

Finally, team members should plan carefully their role in the watershed analysis. The requirements interdisciplinary analysis places on individual members are many. Interdisciplinary team members must be team players who can, in the words of one team leader, "check their ego at the door." Team members should also plan on being good listeners, being patient, communicating with as little jargon as possible, being willing to explain positions and ideas, and being willing to put in the extra effort that interdisciplinary analysis requires (Russell 1982a).

Improving Watershed Analysis

Successful interdisciplinary teams have (1) adequate dedicated time for projects, (2) stable memberships, and (3) institutional support from sponsoring agencies (Luszki 1958, Russell 1982a, Russell 1982b, Chubin et al. 1986, Klein 1990). For the most part, watershed analysis teams have none of these essential elements. The following three groups of recommendations suggest ways to reverse this situation.

Districts should be empowered to provide teams with dedicated blocks of time without distraction to focus on watershed analysis. Adequate time needs to be provided for teams to develop interdisciplinary analysis. Spending too much time on current and reference conditions and not enough on synthesis and interpretation defeats the purpose of watershed analysis for synthesis is the desired product. Adequate budgets can also reduce the strain associated with competing workloads so specialists do not have to "steal time" to work on watershed analysis. Dedicated time should be combined with consistent team membership. This combination can enable interdisciplinary analysis for a number of reasons. The team can focus exclusively on interdisciplinary analysis of the watershed. Team members can have more opportunities to break through disciplinary jargon and communicate effectively. Teams can find enabling techniques that work for them as a team.

Stable memberships are recommended for watershed analysis teams. Especially on districts with a limited pool of specialists to choose from, it is necessary for specialists to develop good communication and mutual respect. Both of these critical issues need to be nurtured. Both need extended periods of time to develop. Stable memberships are more efficient as well. Repeated watershed analyses can enable the team to learn from successes and failures and improve through time.

An important related issue is the selection of the team leader. It is recommended that the Forest Service develop a cadre of team leaders skilled in leading interdisciplinary analysis teams. These individuals should be developed through training, and merit-based promotions and rewards. The rigors of leading an interdisciplinary analysis team of resource specialists on a district causes many team leaders to burn out. Interdisciplinary analysis will be at the heart of future ecosystem management and these individuals will be very valuable assets to the Forest Service.

Interdisciplinary team training is also recommended for teams with stable memberships. watershed analysis is a novel approach to land management for the Forest Service and requires additional training. Team training that recognizes the enabling and disabling factors outlined in this paper can be valuable for future interdisciplinary analyses.

Management needs to become committed to the watershed analysis process if watershed analysis is to succeed. Teams do not perform as well as they can if this support is lacking. Strengthening of the management and team relationship is recommended through establishment of additional protocols by which managers can become more involved in the watershed analysis process. For instance, managers should have input into the recommended planning process for watershed analysis detailed above. Managers also need to have input during the issue identification stage (step two), after the current and reference conditions (steps three and four) and several times during steps five (synthesis and interpretation) and step six (recommendations). This input allows management to ascertain a clearer picture of the complexity and potential of interdisciplinary analysis. Teams can ascertain a clearer picture of management needs.

Management should encourage and reward innovation by watershed analysis teams. Watershed analysis teams and team leaders should also be rewarded for excellent performance. Watershed analysis is a developing procedure and will need refinement for its practitioners as well as its end users. Encouraging development of methods and tools for interdisciplinary analysis can have long-term benefits for the Forest Service.

A larger issue related to institutional support for watershed analysis is the incorporation of watershed analysis into watershed planning. While it is beyond the scope of this paper to make policy recommendations, it is important for management to recognize that teams need to see the results of their work integrated into planning as the Northwest Forest Plan dictates. In that plan, watershed analysis is an integral aspect of watershed planning. However, watershed planning is not being implemented. Successful interdisciplinary teams will need to see the results of their work in watershed planning.

Teams burn out when watershed planning does not occur and their products are wasted. Teams need to be reassured that their efforts are not in vain.

The study's findings warrant the recommendation that the Forest Service begin developing evaluative mechanisms for watershed analysis. Without peer review or evaluation, teams struggle to ascertain what a good interdisciplinary analysis looks like. This feedback is critical for interdisciplinary analysis teams to evaluate their work. Feedback should take place throughout the watershed analysis cycle, not just after products are completed.

It is recommended that the Forest Service engage in knowledge sharing among teams. It would be desirable to create a watershed analysis newsletter and utilize the internet (web page and list-server for example) to enable watershed analysis teams to communicate their successes and failures in developing interdisciplinary analysis for watershed analysis. This type of knowledge sharing can begin to demonstrate models of good interdisciplinary analysis.

By learning what interdisciplinary analysis looks like, watershed analysis teams can be more efficient with their time and produce more useful products. Management can begin to move from the highly subjective "I can not define interdisciplinary analysis, but I know it when I see it," to developing evaluative mechanisms for watershed analysis.

Such changes will require increased costs. These might be easy to justify in light of the resulting increase in the effectiveness of the Forest Service workforce. Specialists are training in ecosystem management. Specialists who have not talked to each other previously are doing so and learning from each other. Management will improve by retaining these generalists. Past mistakes that were founded on monodisciplinary misunderstandings, such as clearing stream channels of woody debris, are less likely to happen when issues receive interdisciplinary scrutiny. Watershed analysis is a good shakeup of functionalism in the Forest Service and provides a valuable intellectual challenge to specialists. Watershed analysis is a way to learn how to think and work to best meet the challenge of sustaining human and ecological needs.

Suggestions for Future Research

The present study is fairly novel in the rich literature of interdisciplinary research. Little research exists concerning interdisciplinary analysis in natural resource management. While this study is consistent with the findings of much of the research about interdisciplinary research, a number of intricacies specific to the field of natural resources management are noted. In particular, watershed analysis takes place in a land management setting, is carried out by teams of natural resource specialists, and is characterized by unique enabling phenomena such as GIS and field trips, and disabling phenomena such as specialists' multiple project workloads. Further research may be useful in view of the increasing demand for these kinds of interdisciplinary analyses.

This exploratory study has revealed a number of factors that enable or disable interdisciplinary watershed analysis. Future research can utilize the factors discovered here to survey a much larger sample of teams to uncover relationships between teams and the products they create. In order to be able to evaluate such products, further development of objective measures of interdisciplinary analysis is needed.

Additional research could track interdisciplinary teams over time to revisit these issues and determine what positive and negative changes are occurring. In order to fully integrate watershed analysis into Forest Service planning, it will be especially important to investigate pervasive disabling factors. Extensive observation of watershed analysis teams could result in less bias due to self-reporting.

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APPENDIX A. Semi-Structured Group Interview Instrument.

1. What techniques did you employ to synthesize information?

2. How did people interact during the synthesis step? Was there an emphasis on working interdisciplinary from the start? Did your discussions modify your individual report for the WA?

3. What guided the team's effort in producing the synthesis?

4. Did people from different disciplines have difficulty deciphering their respective disciplinary languages (lingo)? How did you translate?

5. Which was the hardest step? What made it difficult? What was difficult about the synthesis step?

6. Was it easier for some disciplines to work together than others? To what extent did differing viewpoints concerning resource management influence interactions? If so, did working together enable learning about other disciplines and viewpoints?

7. How did having non-FS personnel on the team affect the process?

8. Was this WA limited by group members' time available to spend on the project? Was it limited by the budget available?

9. Looking back, what would you have done differently? The same?

10. Did you learn anything new about the watershed? Did you learn anything new about how different specialists view the watershed? Did you adjust your learning style to accommodate new knowledges? Do you feel you gained knowledge from the experience? Do you feel that your skills have been enhanced from learning about others' skills/views?

11. Other comments? Questions I should have asked?

12. More specific questions for each question (for terse or no answers).

APPENDIX B. Pre-interview survey instrument.

Biographical Data

Name Age Gender

Race GS-level at time of WA Job Title at time of WA

Professional Area of Expertise (e.g. hydrology, biology, sociology, administrator, wildlife)

Question 1. Which team members did you spend the most time with during the WA?
Rank 1 (least) to 5 (most) next to member names below.

	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

Please list below any members not included in the above list.

	1	2	3	4	5
	1	2	3	4	5

Question 2. With which team members did you have the most valuable interactions with while completing the Watershed Analysis (WA)?

Question 3. Did you benefit professionally from the process of completing this WA? If so, how?

Question 4. Did you personally enjoy working on this WA? If so, briefly explain why or why not.

(over)

Question 5. Did the completed WA fall short, achieve, or surpass your expectations for the level of interdisciplinary integration it should contain? Please explain.

Question 6. What kinds of interactions or circumstances (e.g. field trips, shared office space, etc.) facilitated the group's efforts to produce an integrated analysis?

Question 7. What kinds of interactions or circumstances hindered the group's efforts?

Question 8. What do you think could be done during future analyses to increase the level of interdisciplinary integration?

Thanks for Your Time.
Please return this survey to:

Tony DeFalco
USDA-FS, Redwood Sciences Lab
1700 Bayview Drive, Arcata, CA 95521
FAX (707) 825-2901

APPENDIX C. Human subjects approval.

HUMBOLDT STATE UNIVERSITY
COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH

FORM 3: REQUEST FOR EXEMPTION FOR SURVEY

1. Principal Investigator:

Name: Anthony S. DeFalco
Department: Natural Resources Planning & Interpretation

2. Faculty or Staff Sponsor (students only):

Name: Dr. Leisa Huyck
Department: Natural Resources Planning & Interpretation

3. Other personnel (name. position or class level)

4. Project Title: An analysis of USDA Forest Service Watershed Analyses: A lesson in interdisciplinarity in natural resources management

5. Check all items that apply:

X Master's Thesis or Project
Senior Thesis or Project
Faculty Research
Class Proiect/Course No.
Other (specify):

6. Status of Request (check one):

X New
Renewal
Modification

7. Dates Survey to be Administered:

Begin: May 1998 - January 1999
End: January 1999

8. Subject Population: USDA Forest Service Watershed Analysis teams

Number of subjects: approx. 3 0 - 4 0

9. Method of Administering Survey. Attach explanation.
Group interviews will be conducted at Forest Service sites

10. Survey Instrument and Instructions: Attach explanation.

11. Forward three copies to the College of Natural Resourccs and Sciences (CNRS), Forestry 101.

FOR OFFICE USE ONLY

Approved: ✓ 5-10-99

Expiration Date:

Authorized Signature: Warren Carlson

Denied:

Reason: