Fall 1994

Watershed Analysis in the Federal Arena

Leslie M. Reid and **Robert R. Ziemer**
USDA-Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata
Michael J. Furniss
USDA-Forest Service, Six Rivers National Forest, Eureka

Editor's note: This paper follows from an interdisciplinary and interagency workshop held on 20 April 1994 at the Humboldt Interagency Watershed Analysis Center. The paper expands on discussion topics and adds documentation from other sources with the intent of provoking additional discussion. It is abbreviated from the original paper.

Watershed analysis has become a major preoccupation of federal land management agencies in the Pacific northwest. Even in an era of budget and personnel cutbacks, federal agencies are required to take on new responsibilities and to adopt a new approach to land management and interagency cooperation. Considerable work needs to be done over the next several years, but few understand the type of work required or its intended scope.

The context for watershed analysis

The Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (USDA and USDI 1994; the combined Record of Decision and the Standards and Guidelines are here referred to as the "ROD") describes the new land-management strategy, and presents watershed analysis as an important component of this strategy. Federal lands in western Washington, western Oregon, and northwestern California will be managed according to the environmental needs and opportunities of each area, and watershed analysis is the tool for identifying those environmental needs and opportunities.

The lands to be analyzed

The ROD divides federal lands within the range of the northern spotted owl into key watersheds and non-key watersheds. A variety of reserve types, including riparian reserves, are located within each of these land categories. "Matrix lands" comprise the parts of non-key watersheds that are not included in reserves, and management can proceed in these areas by following the Standards and Guidelines outlined by the ROD. In all other areas, some type of analysis is required before significant management activities can occur. Watershed analysis is required in all key watersheds, and it is also necessary in non-key watersheds if modifications to Standards and Guidelines or riparian reserves are desired. These analyses are to be carried out on 20- to 200-square-mile watersheds by interdisciplinary, interagency teams.

Prioritization of watersheds for analysis

The pilot watersheds were selected on the basis of existing data, access, and the ability for the agencies to cooperatively complete the analyses. Future prioritization is expected to favor those watersheds where completed analyses could lead to many opportunities for projects and employment, or to major improvements for at-risk and threatened or endangered species. Prioritization thus will be based on the interests of many agencies and the public, so it cannot be done effectively by a single agency acting alone. Prioritization would be carried out most effectively at a basin or province scale, and might be guided by the results of basin analysis. In any case, the Local Interagency Implementation Team (LIIT) and the Provincial Interagency Executive Committee (PIEC) should be involved in setting analysis priorities, both to allow consideration of large-scale socio-economic concerns and to promote interagency consensus and commitment.

Relation of the interagency approach to other watershed analysis methods

Other types of watershed analysis are being applied to forest lands of the western United States, or will be in the near future. Unfortunately, none is appropriate for addressing the challenges posed by the ROD. The most thoroughly implemented version of watershed analysis is that being used in Washington state to evaluate cumulative effects in watersheds with multiple land owners. Interdisciplinary representatives of the forest-related interests in each 15- to 80-square-mile watershed work together to identify causes of environmental change and to define area-specific standards and guidelines that would avoid detrimental changes. Evaluation focuses on the effects of timber management on fisheries and water quality; wildlife issues are not addressed. Adherence to the analysis recommendations is voluntary, with the incentive that those following the recommendations will need no further environmental assessment work. No restrictions are placed on what land uses are allowed at what times at particular sites. Instead, guidelines describe how activities should be carried out in different parts of the watershed. Analysis is carried out for all lands, public and private, in the designated watersheds. A manual for analysis has been published that contains a set of modules for evaluating slope stability, sheet erosion, hydrologic change, riparian function, and aquatic habitat (Washington State Forest Practices Board 1993). Methods were selected that compilers believe to be effective and practical in Washington, and the manual is updated frequently as methods are modified. A week of training introduces analysts to the procedures in the manual, but each analyst is expected to have adequate training in their own field. In practice, most analyses have been carried out by highly experienced specialists, and methods have not been limited to those outlined in the manual.

The Washington approach is not directly applicable to needs of federal land management for several reasons. First, it does not address the full range of issues that must be considered on federal lands, where wildlife and social issues are accorded as much attention as aquatic issues. Second, the approach assumes that types of land-use activities will not be proscribed anywhere in the watershed, although the way that they are carried out can be controlled by prescribing on-site Best Management Practices. On federal lands, however, a much broader range of management options is possible. The distribution and timing of activities over large areas can be scheduled on federal lands, and some activities can be proscribed completely. Planning for scheduling or proscription requires some information that is not necessary for the design of on-site Best Management Practices. Third, the Washington manual includes the methods that were selected to suit Washington conditions, and many of these methods are not flexible enough to apply to areas of as diverse character as occur throughout the range of the northern spotted owl. Fourth, the Washington method results in a land-use prescription instead of simply describing the functioning of the ecosystem and watershed, and thus goes beyond the intent described by the ROD.

Despite the differences in intended application, elements of the Washington approach were used in the design of the interagency approach to watershed analysis. In particular, its recognition of the importance of including multiple interest groups, its use of interdisciplinary teams, and its focus on understanding general patterns of process interactions throughout a watershed are shared by the interagency watershed analysis procedure. A watershed analysis procedure is also being developed by the National Council of the Paper Industry for Air and Stream Improvement for use on private timberlands in the western states (NCASI 1992). This method is expected to be similar to the Washington approach, but will address a wider variety of environmental issues. A prototype of the method is expected within the next several years.

The concept of interagency watershed analysis

There is no widely shared image of what watershed analysis is, so people have different expectations of what an analysis should include. It will be necessary to educate those with inaccurate expectations of watershed analysis, and to make it clear that analyses will depend primarily on existing data and will not take the place of analyses required for project-level planning.

Goals of watershed analysis

Many hold the misconception that a watershed analysis will take the place of project-level data-gathering and analysis, although the ROD clearly states that watershed analysis is intended primarily to disclose patterns of process interactions and ecosystem function. One objective of analysis is to identify the types of information needed "for subsequent analyses, planning, or decisions" (ROD p. E-21, par. 1). Watershed analysis itself "will be an information-gathering and analysis process, but will not be a comprehensive inventory process" (ROD p. E-20, par. 6). In general, it will "organize, collate, and describe existing information", although if crucial information for the analysis is lacking, completion of the analysis may be postponed until it is available (ROD p. E-21, par. 1). Extensive data sets already exist for many areas, but resource specialists rarely have had time to examine the broader implications of these data or their interdisciplinary significance. Watershed analysis will provide a framework for making these connections. One function of watershed analysis is to guide future monitoring and inventory by disclosing data gaps, describing large-scale and interdisciplinary relationships, and identifying the information necessary to better understand the watershed and ecosystem. In essence, watershed analysis identifies what we don't know and determines how badly we need to know it. New information will thus continue to become available after a watershed analysis is "completed", and subsequent project-level analyses will use both information from the watershed analysis and the supplementary data. Project-level analyses will also add site-specific data to the watershed database. In some cases, the importance of new data or changing issues may make it useful to reevaluate parts of the original analysis or even to update the entire document. A watershed analysis should thus be considered an open file, and it is described by the ROD as "an ongoing, iterative process" (p. E-20, par. 6).

Watershed analysis is intended to describe the conditions, interactions, and causes of change in a watershed. It is not intended to recommend land-use allocations by delineating reserve boundaries; this is the function of site analysis and project planning, which must adhere to NEPA requirements for review and oversight. The two over-riding requirements of the analysis are that it be interdisciplinary and that it include input from multiple agencies. Many worry that watershed analysis results will not be precise enough to be useful, and that analyses will need to be redone to design particular land-use projects. For example, watershed analysis will not produce a landslide map, so landslides will eventually need to be identified at each project site as the project is planned. However, this would be necessary even if each landslide in the watershed had been mapped during watershed analysis, since any landslide map is out of date as soon as a new slide occurs. Such site-level detail is not the intent of watershed analysis. Instead, analysis will show the broader patterns of cause and effect so that future project analyses can focus on the site-specific issues. For example, watershed analysis might describe the types of sites susceptible to landsliding in an area and describe the land-use activities with which the slides are associated. Project analysis would then use this information to aid in evaluating stability conditions at the project site.

Others suggest that such a broad overview can only disclose the information we already know to be true, such as the observation that environmental conditions improve when sediment loads decrease. However, many of these "facts" are found in retrospect either not to be true or to apply only to particular sites. At one time, for example, we "knew" that woody debris is bad for fish and so has to be cleared out of streams, and that 12% roaded area increases peakflows; a high proportion of the educated public still believes that logging decreases baseflows despite 50 years of research literature to the contrary. Each of these assumptions must be reexamined in the context of particular watersheds. In addition, there are many places where the major ecosystem problems arise from obscure interactions that would not be recognized without an interdisciplinary analysis. To restore a stream channel, for example, we must understand what caused it to destabilize in the first place, and this usually requires a sophisticated understanding of riparian vegetation, sediment transport, and basin hydrology.

Watersheds as analysis units

Watersheds have been adopted as the geographic unit for evaluating habitat needs and abundance of many organisms, such as the spotted owl, that are not directly affected by watershed processes. Wildlife biologists understandably ask the question, "Why should our analysis be constrained by watershed boundaries when our organisms are not?" Similarly, social and economic issues have little relation to watersheds, many physical processes are better described according to geologic and climatic types that cut across watershed boundaries, and anadromous fish stocks require information from multiple river basins to understand their conditions. Not only does each issue have a different scale that is relevant to it, but each issue must be examined at several different scales if it is to be understood.

At the same time, it is essential that interdisciplinary evaluation be brought to bear on the suite of issues important in a particular area if those issues are to be understood. For example, to understand the history, distribution, and future of physical impacts in an area, it is necessary to understand the history of land use there, the economic setting, and the biological changes that have occurred there. Since no single area is appropriate for all issues, it does not really matter what size of area is selected or how it is delineated. In essence, the fundamental understanding that has been derived by each discipline using the scales relevant to that discipline is applied to the area in question. For the present application, 20- to 200-square-mile areas were selected as being small enough to analyze at a useful scale of precision, while being large enough to exhibit the interactions important to environmental issues. Watersheds were selected as the analysis unit because they come in convenient sizes, they are identifiable on maps and on the ground, they do not change much through time, and they hold relevance to off-site effects that influence biological, sociological, and physical processes. An important driver of physical, biological, and economic issues is the change of channel morphology brought about by upstream changes in physical, biological, and land-use conditions. To understand these changes, it is necessary to understand the physical, biological, and socio-economic conditions in the channel's watershed. Since downstream changes (cumulative watershed effects) are an important consideration everywhere and would need to be evaluated in each analysis area, it makes sense that the arbitrary analysis unit could be selected to make this type of analysis possible. Cumulative watershed effects strongly influence floodplain land use, aquatic and riparian biological communities, and the terrestrial ecosystems that depend in part on riparian and aquatic communities.

In addition, many terrestrial concerns reflect watershed boundaries even if they are not bound by them. Migration routes often follow riparian corridors, and some wildlife territories stop at watershed boundaries. Even transportation routes and local economies tend to be focused within watersheds.

Analysis watersheds may range between approximately 20 and 200 square miles, and the majority are expected to fall between 50 and 150 square miles. The size range was selected specifically to keep the analyses relevant to the types of problems it is intended to address. Analysis watersheds need to be large if the connection between land-use activity and impact is to be explained. Many past analyses have failed simply because they focused on too small an area for the important processes to be recognized.

Because of the strategy used in analysis, the size of the area to be evaluated does not hinder evaluation. Large areas can be divided into smaller areas of uniform character, and representative sites in a subarea can then be observed to characterize that subarea. Large areas can be evaluated using this "landscape stratification" approach almost as quickly as small ones. In addition, analyses are intended to show distribution patterns and qualitative categories, not specific locations or detailed measurements. Analysis focuses on which processes are active and how they generate impacts, not on how rapidly they operate at particular sites. Patterns often are easier to recognize and understand in large areas than in small ones.

The issue focus

Watershed analysis is to be carried out for large areas over short periods of time. Analysis is greatly simplified if it concentrates on only the most important issues in an area. A first step of watershed analysis is thus to use public outreach to identify the issues of concern in and around the analysis watershed. Other issues of concern at the scale of the river basin are identified during basin assessment, and the watersheds in which these issues will need to be considered are also identified at this stage. An additional set of issues are those already well-known to the various disciplines carrying out the analysis: water quality, biodiversity, threatened species, and so on. A final set of issues that might be important in the future can be identified according to the trends in socio-economic, biologic, and physical conditions in the watershed. The analysis will then be planned so that it will be capable of speaking to the identified issues. In most cases, the list of issues can be prioritized to more closely focus the analysis. Without this type of prioritization, it is very easy for analysts to be carried off by the details they recognize in their area of expertise. Related to the need for focus is the need to avoid gratuitous detail. In many cases, only qualitative information or order-of-magnitude measurements are needed to address the problems. This is a difficult concept for most experts: our training has primarily been in observing the fine details of our problems, in the need for precise and accurate measurements, and in the need for large data sets. Watershed analysis demands that analysts step back from the detail and define general patterns and relative importance. The appropriate level of effort or detail must be judged by its relevance to the problem at hand, rather than by the attainable precision or by the possibility that a piece of information might be useful in the future.

Time required for a watershed analysis

The specialists' desire for detail and precision argues for a lengthy time commitment for completion of a watershed analysis. However, land managers see watershed analysis as a hurdle to be leaped before any activities are carried out, so there is strong pressure for analyses to be completed quickly. A watershed analysis could take decades to finish, or it could be completed in a day. These products would differ primarily in their level of detail; both would be useful for particular applications, and neither would be complete. Ultimately, the usefulness of an analysis will be judged by how well it meets planning needs, and these needs include both timeliness and detail. Two months was selected as a period over which a useful level of detail could be achieved for identifying appropriate future projects, but which would allow the majority of analyses to be completed during the next ten years. In a few cases, the expected two-month duration for analysis may not be appropriate. Some areas may need only a brief examination of a few key issues, while others may involve such complex problems that more time is required. Different parts of the federal landbase may be better suited by different levels of analysis detail. For example, problems in national parks are often concentrated in a few watersheds, and park personnel may be able to devote long periods to their detailed analysis. The earliest analyses are expected to take longer than later ones as methods and approaches are developed.

Experience with ongoing watershed analyses suggests several ways to expedite analysis. Abundant data exist for many areas, but it takes a long time to find and catalog the information so that it can be used. A pre-analysis scoping of issues could prioritize data types so that most effort could be devoted to the most useful data, and data compilation could then begin long before the actual analysis. This preliminary scoping might be a part of basin analysis. Some types of information are likely to be important for all analyses, and once these are identified, data compilation for any future analysis could begin. The most useful first step in data compilation often is to identify people who are experts in aspects of the watershed. A second trick for simplifying analysis is to divide ("stratify") the watershed into areas ("strata") that behave uniformly with respect to a particular issue. Observations of representative sites within each stratum can then be used to characterize the stratum. Different stratification schemes would be used for different issues within a single watershed.

Several early analyses have suffered from awkward budgeting of efforts: parts of the analysis that were expected to be accomplished in several days have taken months. It may be useful to establish a timeline that indicates the level of effort expected for different parts of the analysis. An early draft of the Pilot Interagency Watershed Analysis Manual (Reid and McCammon 1993) suggested the following time budget: Stage 1: Preliminary work: accumulate and catalog available information (occurs simultaneously for several watersheds over several months); Stage 2. Identify issues and concerns (approximately 1 week); Stage 3. Identify mechanisms through which environmental change could occur and use this information to plan analysis strategies (approximately 1 week); Stage 4. Stratify the watershed according to important issues (less than a week); Stage 5. Describe existing conditions (4 weeks, with stages 6 and 7); Stage 6. Describe the mechanisms of environmental change (see stage 4); Stage 7. Describe likely future environmental changes (see stage 4); Stage 8. Prepare report (approximately 1 week). Later versions of the manual have modified the stages of analysis, but the relative effort to be put into each phase is clear. A lot of time will be devoted to the preliminary identification of available data (stage 1), which can then be used to identify and plan the work that needs to be done (stages 2-4). Interdisciplinary analysis (stages 5-7) then accounts for half the time budget. The preliminary data compilation can occur at one time for many different watersheds, and it does not require much oversight by the specialized watershed analysis teams.

Consistency and standardization

Watershed analysis is complicated because every watershed has a unique set of characteristics, conditions, processes, and issues. It is thus futile to collect the same types of data, perform the same analyses, and use the same methods in each watershed. However, some consistency is required so that results can be compared for watersheds throughout a river basin or region. Standardization falls into three categories: data standards, method standards, and product standards.

Because watershed analysis is not itself a data-gathering exercise, data standards are not of direct concern to analysis. However, watershed analysis uses existing data and would thus be easier if inventories and monitoring adhered to uniform standards. Data are most easily compared if they share a uniform precision, accuracy, scale, and format, and if they are collected using standard methods. On the other hand, issues present in one area may demand more detailed information than in others, so there is no single data standard that is appropriate for all issues in all areas. Data collection usually is guided by the discipline most concerned with a particular type of data, and often the information is collected in a form that makes it useless to other disciplines. Interdisciplinary communication during watershed analysis will allow future data collection efforts to be designed to meet the needs of multiple disciplines. Future analyses would be facilitated if data standards and standardized measurement techniques were established for commonly inventoried attributes.

Many watershed analyses will use GIS for data compilation and analysis, and GIS introduces additional demands for standardization. Many types of data are not readily managed using GIS, and it is important to preserve the original integrity of the data rather than translating them to the uniform scales that GIS often demands. GIS is a useful tool for data compilation and analysis, but it is not a prerequisite for watershed analysis, and its requirements and limitations should never control the analysis. Spatially explicit information is rarely necessary until particular projects are proposed, and the site-specific information required for project design cannot be attained at the scale of watershed analysis.

Watershed analysis methods also cannot be standardized because of the variety of issues and settings that analyses will address-no method will be valid for every site. However, some consistency of analysis is necessary to communicate and compare results. Consistency will come about because analyses are to be conducted by competent experts in the appropriate disciplines, and each analyst will use methods consistent with the standards in their field. Within this broad guideline, analysts must have the freedom to use methods appropriate for the setting. In particular, each issue will require examination at the scale relevant to it, and different analyses will provide different levels of detail for particular problems. Quality control is introduced because methods must be carefully described and must stand up to peer review. As experience grows, certain approaches will be found to be particularly useful, and eventually a suite of methods may become widely applied. Standardization may thus eventually occur through peer review. The lack of a "cookbook" is expected to benefit the analyses: cookbook methods tend to be applied blindly without judging their appropriateness, and they prevent people from seeing the unique opportunities for understanding that each area possesses. In addition, premature selection of a standard method may institutionalize an invalid procedure and prevent its bias from being assessed. The most useful "manual" in the long run may simply be examples of successful analyses that exhibit a wide variety of useful approaches and methods.

Even standards for an analysis product are not particularly useful, since areas rich in data will allow detailed analyses while data-poor watersheds may permit only a broad analysis. What is essential, however, is a standardized vision of how the analysis product will be used. Standardization is again primarily useful for communicating and comparing results, and this is particularly important for allowing aggregation of watershed information at the basin level. A product of basin analysis could be a description of the types of information that need to be standardized during watershed analysis to address issues at a basin scale. The most effective route to a useful level of standardization may well be simply to arrange meetings of a variety of analysis groups to allow critiques of methods, sharing of useful techniques, and comparison of analysis products. The most useful approaches and methods will be converged on-standardized-through repeated comparisons.

Interagency participation

Many key agencies are understaffed even for their existing workload, and they have little inclination to expand the workload to beyond what they already do not have time to do. Federal agencies will participate if they see the analysis as a way to achieve their agency's goals or if they are told to participate by Washington D.C. Through FEMAT (Forest Ecosystem Management Assessment Team), Washington has directed federal agencies to accept watershed analysis as a priority, but the degree and manner of each agency's participation remains unclear. State agencies have no mandate to participate and are likely to be involved only if it satisfies their needs. Lures for participation might include the general utility of a better information base, and the extent to which watershed analysis can contribute to state requirements for land-use planning or regulation. A promise of economic return also motivates many groups to participate: the LIIT meetings have garnered great interest because of their role in distributing money and jobs for watershed restoration.

Despite the uniformity of vision mandated for federal agencies, the imbalance between obligation and workload remains an issue. Some agencies simply do not have the staffing or budget to participate in analyses. Many of these agencies retain an important role, however, in that they participate on the Regional Interagency Executive Committee that reviews proposed actions to determine whether they are consistent with the objectives of the ROD. Mechanisms therefore must be found to bring all interested agencies together to agree on an analysis approach in a watershed, and the agencies must be kept informed as analysis progresses. Agencies are likely to participate more intensively only if they manage or have regulatory responsibility for land within the watershed. Prioritization of watersheds for analysis must take into account the interests and capabilities of the interested agencies. Analysis would be aided if agency responsibilities and commitments are clearly stated for each watershed by PIEC when watersheds are prioritized for analysis.

Federal watershed analysis and private lands

Watershed analysis must evaluate all lands within a watershed, and some of this land is likely to be privately owned. Information about private lands provides the context for judging the influence of federal land management and is essential for interpreting off-site effects.

Since only representative sites need to be visited, lack of access to private lands usually does not hinder analysis. Much of the information necessary for analysis is available on aerial photographs or can be inferred from data from adjacent federal lands. In other cases, on-the-ground information may be needed, or the landowner may own data sets relevant to the analysis. The Record of Decision states that public input is important for watershed analysis, and strong efforts should be made to encourage cooperation with private landowners. It will usually be in the landowners' interest to participate, because the resulting database and analysis will be useful for planning management and completing cumulative effects evaluations. If landowners are unwilling to cooperate in the analysis, it may be necessary to assume a worst-case condition for the inaccessible lands, but it is important to identify such assumptions in the analysis and to assess the sensitivity of results to the assumptions.

Analysis applications

The ROD establishes watershed analysis as a source of information to be used to help plan Riparian Reserves, restoration programs, and monitoring. Analysis is also intended to provide information about process interactions, causes of environmental change, and ecosystem function that will useful for more generalized land-use planning.

Every interest group has tended to assign to watershed analysis the tasks that would most benefit the goals of that group. Planners would like watershed analysis to produce land-use plans, managers want it to delineate the boundaries of Riparian Reserves, USF&WLS would like it to provide enough information for consultations, and resource specialists want the analyses to provide the level of detail needed for project-level planning. The Record of Decision indicates that all of these expectations are unfounded: watershed analysis will provide information on general ecosystem and physical interactions, but will not contribute comprehensive inventory information or take the place of project-level data collection.

Understanding ecosystems

Watershed analysis will identify what information exists about aquatic and terrestrial ecosystems, what is needed, and what the likely fish and wildlife issues are in different parts of the watershed. Analysis may identify and prioritize the types of inventories and monitoring information needed, identify areas of particular importance, and indicate the type of information needed for project-level planning. Results of a watershed analysis might be used to justify a watershed-scale survey to determine the distribution of particular species.

The watershed analysis can be amended as additional information becomes available from future inventories, monitoring, and project-level analysis. However, there will never be enough on-the-ground data available for a "complete" analysis, so it is important for analysts to identify the information they do have, and to restrict inferences to those that can be supported by existing data. Habitat models are useful only if they have been well tested and if sufficient data exist for their valid application in the area. Most watershed analyses will incorporate little fieldwork, and much of the field time should be devoted to developing cross-disciplinary understanding rather than to addressing problems peculiar to a single discipline. We know we're good at data collection, but now is the time to tackle the more difficult task of integrating and interpreting the information we have. If watersheds are prioritized for analysis early, then useful discipline-specific data can be collected in preparation for future analyses.

Cumulative effects analysis

Cumulative effects analysis cannot be completed during watershed analysis because they deal with effects of particular projects, and future projects are not known at the time of watershed analysis. However, watershed analysis results will be useful during future cumulative effects analyses anywhere in the watershed. Watershed analysis will have identified existing data, described the nature and cause of existing cumulative effects in the watershed, and described the interactions that could cause future impacts. New cumulative effects procedures are likely to be developed that will take full advantage of this information. In the meantime, any existing cumulative effects methods can make use of watershed analysis results. For example, watershed analysis would provide much of the watershed-scale information necessary for cumulative effects evaluations of California Timber Harvest Plans, and this will decrease the work necessary for THP completion. This role for watershed analysis may encourage state agencies to participate in watershed analyses.

The Washington state watershed analysis approach has been adopted as a cumulative effects procedure by consensus of the disparate interest groups in the state. As discussed above, this approach could not work on federal lands because the context for federal land management is different than that for state and private lands. The Washington procedure results in a set of Best Management Practices tailored for different parts of a watershed, but it does not specify when or how the lands can be used. Federal lands have a wider variety of management options than private timberlands, however, and this range cannot be addressed by prescribing Best Management Practices. In addition, management strategies are changing rapidly on federal lands, so the potential for environmental change will need to be reassessed for each future project according to the conditions at that time.

The stumbling blocks

Watershed analysis is new. Federal agencies have no history of such analyses, but they are now required to produce hundreds of analyses over the next several years. A humbling variety of analytical, cultural, and procedural challenges will need to be overcome before watershed analysis becomes recognized as a routine phase of management planning.

Everyone has a different vision of what analysis should be, so everyone can be assured that analysis results will fall short of their expectations. Efforts must be made to explain that watershed analysis is simply a description of the environment and how it works; it is essentially a conceptual inventory of watershed and ecosystem functions. It is a planning tool, and not a planning product.

The major analytical hurdles center on the need for an interdisciplinary approach and on the size of the area to be evaluated. Because of our culture's mono-disciplinary approach to education and the requirements of specialization, most resource specialists have little experience with true interdisciplinary problem solving. Past interdisciplinary efforts have often led instead to multidisciplinary work, where representatives of different disciplines all simultaneously and independently examine the same area. We still have a tendency to believe that we are capable of solving our part of the problem, not realizing that we do not have a part of the problem because the problem does not have discrete parts. Until resource specialists can look at a problem and see a web of interdisciplinary relationships, individuals will need to work hard to peer beyond their own disciplinary boundaries and communicate with other team members. Meanwhile, terrestrial biologists fail to see the relevance of hydrologic and geomorphic change to the issues they are concerned with; aquatic biologists do not consider the controlling influences of terrestrial ecosystems; and few understand the pervasive role of the social setting and cultural history in determining both past, present, and future ecosystem characteristics.

The scale problem is another one inherited from the western philosophy of science: we are more comfortable with looking carefully at small things than with getting a broad overview of a large thing. We are taught to value precision and accuracy in detailed measurements, and these are then assembled as pieces of a conceptual jigsaw puzzle to eventually make the "big picture" understandable. Watershed analysis takes the opposite approach. Here, the emphasis is on recognizing the broader patterns of interactions to identify which are most critical to understand at what level of precision. It is difficult for us to grasp the realization that for many applications, we may need only qualitative or order-of-magnitude information; or that we may not need to know the precise location of a feature to understand its role in the overall system. We tend to approach the world through inventory and mapping, while watershed analysis makes use primarily of pattern recognition and sub-sampling to characterize the elements of the patterns. Watershed analysis proceeds simultaneously at multiple scales, and this approach is an unfamiliar skill that must be acquired through practice.

Some of the agencies that are intended to participate in watershed analysis have not accorded it the importance that the primary land management agencies have. Even within the BLM and Forest Service, there is a variation between administrative units in the staffing provided and their mandate. In some Forest Service districts, analysis is being seen as simply a variation of the ID-team work done in the past. Managers expect that their resource specialists can do their watershed analyses in isolation while keeping up with their other assigned duties. At the other extreme, some administrative units perceive watershed analysis as a massive, one-time "campaign," akin to a large fire suppression effort, that can be dealt with by devoting large teams and budgets to getting it done so that normal business can be resumed. Both approaches miss the point: watershed analysis is now normal business, and it is new normal business.

Future analyses will become easier when agencies develop mechanisms for staffing and funding analyses at appropriate levels as part of their normal operating procedure.

Watershed analysis requires an uncustomary level of communication and cooperation between agencies and between agencies and the public. Both present hurdles to agencies that are used to viewing "outsiders" as obstructions to their management goals. Within agencies, there are strong institutional barriers to sharing resources or personnel; agency employees and equipment are expected to work on agency lands. In at least one case, agency employees have been prevented from participating in FEMAT-related efforts in the absence of a letter of understanding between two agency's Washington offices. Personnel of land management agencies still often perceive the regulatory agencies as obstacles, and avoid contact with them in the belief that participation of the regulators will ensure that nothing is ever accomplished. The public is also viewed with mistrust. Agency personnel expect the public to sabotage progress in the interest of personal agendas, and the recent "bipartisan" slate of lawsuits against the ROD support this fear. Agency personnel also have a widespread and erroneous perception that the Federal Advisory Committee Act disallows public participation in watershed analysis except in the customary form of public meetings. Some efforts at issue identification have thus been carried out with no public input at all.

In all cases, the final arbiter of what is appropriate, sufficient, and useful in an analysis is how well that analysis achieves its goals. It is likely that attitudes currently hindering analysis will change only when it becomes apparent what the most useful analyses look like.

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