Bringing the Aquatic Sciences into NFMA Framework: Will They Fit?

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James Sedell & Kelly Burnett, *Bringing the Aquatic Sciences into NFMA Framework: Will They Fit?*, *in* THE NATIONAL FOREST MANAGEMENT ACT IN A CHANGING SOCIETY, 1976-1996: HOW WELL HAS IT WORKED IN THE PAST 20 YEARS? WILL IT WORK IN THE 21ST CENTURY? (Natural Res. Law Ctr., Univ. of Colo. Sch. of Law 1996).

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I. Summary

Over the past twenty years of the NFMA implementation, much has been learned about aquatic ecosystems and the potential for impacts of land management activities. This paper describes key scientific principles of aquatic system function, and how these may or may not have been incorporated into management under the NFMA and its regulations. In addition, considerations for land management are suggested that advance aquatic ecosystem protection and conclusions are drawn regarding the ability of National Forest planning to accommodate these considerations.

Key principles of aquatic ecosystem function include: 1) Aquatic systems, particularly streams and rivers, are best thought of as spatially nested hierarchies with systems at higher levels forming the environment of and constraining subsystems at lower levels. 2) Longitudinal (upstream-downstream), lateral (riparian and floodplain), vertical (hyporehic and upslope), and temporal connections are critical to aquatic ecosystem function. Linkages that operate over shorter intervals of space and time and are the most direct tend to have the greatest influence on the physical structure and biotic community. 3) Natural disturbance is a critical process that shapes landscapes and delivers essential habitat forming elements such as wood and boulders. Aquatic biota are adapted to the natural disturbance regimes under which they evolved. 4) Diversity is expressed simultaneously across multiple organizational and spatial scales (gene, population, metapopulation, species, community, ecosystem, and landscape). Preserving

diversity both above and below the species-level is essential to ensure persistence of many aquatic species including salmon and trout. 5) Scientific understanding is rarely static or complete.

Conservation of aquatic resources has long been a Congressional priority for National Forest System lands (e.g., Organic Act (1897) and Multiple Use Sustained Yield Act (1960)), yet the National Forest Management Act (1976) and its Regulations (1982) were the first attempt to codify how aquatic system conservation might be achieved. Some of the most relevant issues to aquatic resource protection that the NFMA and other statutes may or may not address are: multi-scale planning, individual and cumulative effects of land management, natural disturbance, diversity, and inventory and monitoring.

Management decisions that have the greatest opportunity to foster conservation of aquatic resources and prevent cumulative effects are those: 1) made within the context of higher level analysis and plans for ecologically relevant units, such as watersheds and river basins; 2) that incorporate an understanding of connectivity, are tailored to a particular watershed, and consider conditions on all lands within watershed boundaries regardless of ownership; 3) that recognize and preserve elements of the natural regime such as timing, intensity, extent, and type of disturbance; 4) that are directed at conserving aquatic ecosystem function; 5) that are outcome-based and coupled with specific criteria for judging success, providing that inventory data adequate to develop such plans is available and monitoring of sufficient sensitivity is conducted to yield results that allow timely corrective actions.

The NFMA actually provides very little guidance for protecting aquatic resources, deferring any prescriptive language to be crafted in the regulations. To the benefit of those that develop, implement, and evaluate National Forest land management plans, the regulations do offer specific direction for issues of diversity, monitoring, and multi-scale planning. Although, the boundaries defined for multi-scale planning are not coincident with hydrologic boundaries, nothing in the law or regulations prohibits using ecologically relevant boundaries for analysis and planning and subsequently aggregating such units to plan for current administrative units. The regulations basically restate language in the NFMA for water resources and offer less guidance for protecting natural disturbance regimes. While this lack of direction has resulted in inconsistent and often ineffective protection of aquatic resources, it also allows the flexibility for accommodating scientific advances into management. If the NFMA and the regulations are not modified to incorporate specific direction that reflects current understanding of aquatic systems and the potential for land management impacts to them, then through the latitude granted by these instruments, aquatic system protection may be attained. This is evidenced by the ability, under the current legal framework, to develop scientifically credible regional aquatic conservation strategies such as that contained in the Northwest Forest Plan.

II. Key Scientific Principles of Aquatic System Function

1) Aquatic systems, particularly streams and rivers, are best thought of as spatially nested hierarchies with systems at higher levels forming the environment of and constraining subsystems at lower levels.

2) Longitudinal (upstream-downstream), lateral (riparian and floodplain), vertical (hyporehic and

upslope), and temporal connections are critical to aquatic ecosystem function. Linkages that operate over shorter intervals of space and time and are the most direct tend to have the greatest influence on the physical structure and biotic community.

3) Natural disturbance is a critical process that shapes landscapes and delivers essential habitat forming elements such as wood and boulders. Aquatic biota are adapted to the natural disturbance regimes under which they evolved.

4) Diversity is expressed simultaneously across multiple organizational and spatial scales (gene, population, metapopulation, species, community, ecosystem, and landscape). Preserving diversity both above and below the species-level is essential to ensure persistence of many aquatic species including salmon and trout.

5) Scientific understanding is rarely static or complete.

III. The Legal and Regulatory Context for Aquatic System Protection

1) Conservation of aquatic resources has long been a Congressional priority for National Forest System lands as most clearly expressed in the:

> Organic Act (1897) - "No National Forest shall be established, except to improve and protect the forest within the boundaries or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States."

And

Multiple Use Sustained Yield Act (1960) - "It is policy of Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, wildlife and fish purposes."

2) The NFMA (1976) and its regulations (1982) were the first attempt to codify how aquatic system conservation might be achieved on National Forest System lands. The issues that are most relevant and the provisions of this and other statutes that may or may not address them are:

A. Multi-scale Planning - The approach of staged decision making described in the NFMA (National, Forest, and site) is well founded. It is, however, inconsistent with the nested arrangement of aquatic ecosystems (Warren and Liss 1983, Frissell et al. 1986) and provides inadequate context for Forest and site level decisions. The regulations improved upon this planning hierarchy by adding Regional Guides to bridge national and Forest direction. Planning to implement ecosystem management and conserve aquatic resources could be further enhanced if boundaries were made ecologically relevant (i.e., National, Regional, Provincial/Basin, Watershed, site), with higher level plans providing context for the specificity in lower level plans (Forest Ecosystem Management Assessment Team (FEMAT) 1993). Analysis and planning at the watershed level can provide the context required for determining where actions should take place and addressing cumulative effects under NEPA. It is impossible to adequately consider and resolve at the Project level many of the more complex forest management issues. Nothing in the NFMA or the regulations prohibits aggregating information from ecologically relevant units when planning for administrative units as they are presently defined. Recent large-scale federal, interagency planning processes (e.g., Northwest Forest Plan (ROD 1994) and the Draft Interior

Columbia Basin Ecosystem Management Plan (ICBEMP)) focused on hierarchical analysis and planning along ecologically relevant boundaries.

B. Individual and Cumulative Effects -

1. The NFMA emphasized the national goal of protecting soil and water resources and provided direction to translate this goal into regulations enabling its achievement through Forest Plans. The NFMA Sec. 6. (g) (3) (E) requires regulations be developed to insure that timber is harvested from National Forest System lands only where - "(I) soil, slope, or other watershed conditions will not be irreversibly damaged; and (iii) protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat."

The regulations repeatedly restate general NFMA language to protect aquatic resources. The only additional substantive guidance (36 CFR 219.23 and 219.27) relies primarily on other sources or agencies and simply requires: 1) compliance with all existing federal, state, and local clean water laws; 2) adoption of measures in executive orders "to minimize risk of flood flows, to restore and preserve floodplain values, and protect wetlands;" 3) that special attention be given to land and vegetation for approximately 100 feet from the edge of all perennial streams, lakes, and other bodies of water and topography, vegetation type, soil, climatic conditions, management objectives, and other factors be considered in determining what management practices may be performed within these areas or the constraints to be placed upon their performance; 4) that conservation of soil and water resources be guided by instructions in official technical handbooks that show specific ways to avoid or mitigate damage, and maintain or enhance productivity on specific sites.

Variation observed among Forest Plans is an expression of the scant direction for aquatic resources in the regulations. The lack of guidance may have been appropriate for the time in that it allowed flexibility and experimentation during a period when today's foundation for understanding stream ecosystems was being established. Since the NFMA was signed and the 1982 regulations adopted, much has been learned about aquatic systems and how to prevent land management impacts (Karr et al. 1986, Meffe 1990, Moyle and Sato 1991, Hughes and Noss 1992, Reeves and Sedell 1992, Rinne 1992, Williams and Williams 1992, Doppelt et al. 1993, Frissell 1993, Rieman and McIntyre 1993, Henjum et al. 1994, Botkin et al. 1995, Reeves et al. 1996, Nielsen et al. 1996). The Aquatic Conservation Strategy (ACS) (Northwest Forest Plan ROD 1994) and the interim PACFISH strategy (1995) are regional responses to this history of variable and often inadequate protection of soil/water and fish/wildlife resources in Forest Plans. Both of these regional approaches employed many of the elements about which there is an emerging scientific consensus regarding their importance to aquatic conservation (Bisson 1996): sound description of aquatic ecosystem sustainability objectives; riparian areas defined on the basis of functions provided to aquatic systems; standards and guidelines for riparian area management; requirements for ecologically meaningful analyses to include in Forest Plans; instructions to identify and protect refugia, biological "hot spots", and connectivity; and watershed restoration. Although such scientifically credible regional strategies were developed under the NFMA and the current regulations, if a goal of National Forest management is to increase consistency in aquatic ecosystem protection, then codifying knowledge to benefit and direct the next round of planning seems appropriate.

2. Neither the NFMA nor its regulations make direct mention of cumulative effects. The regulations do recognize the need to coordinate planning with local, state, and other federal agencies, as well as, with private owners of lands that are intermingled with or dependent for access upon National Forest System lands; and require monitoring and evaluation for effects of National Forest management on lands influenced by those for which plans are being developed and the effects of nearby activities on National Forests.

Although the NFMA and its regulations do not explicitly prohibit cumulative effects, to the extent that the National Environmental Policy Act process is capable of revealing such effects incompatible with substantive multiple use standards, cumulative effects are implictly prohibited. Consequently, preventing cumulative effects of National Forest management to watershed and aquatic resources has been dependent upon direction in the National Environmental Policy Act and the Council of Environmental Quality regulations and evolution of case law (e.g., Jersey Jack, Mapleton, G-O Road (Craig 1987).

A more direct route for protection might involve guidance based on recent scientific advances regarding cumulative effects. Such knowledge includes that: 1) Cumulative effects are best detected when the analytical unit is biophysically relevant - in aquatic systems this is the watershed, delineated using hydrologic boundaries that are coincident with boundaries of driving processes; 2) The size of watersheds affects the ability to discern impacts; those that are too large mask cumulative effects by dilution and those that are too small do so by excluding from analysis other, potentially impacting, activities. Thus, intermediate sized watersheds (50 - 100 square miles) are logical units for understanding the potential of management actions to cumulatively affect aquatic systems; 3) There is no universally accepted approach to assess or set thresholds for cumulative effects. The types and accuracy of information required as baseline and monitoring data to detect impacts is often lacking; 4) Riparian and upslope zones have been identified for contributing elements necessary to develop high quality aquatic habitat. Furthermore, the most likely routes by which these zones are linked to the aquatic system and the most likely effects of impacting these zone have been established (Benda 1985 and Benda 1990).

C. Disturbance - The NFMA was crafted within the scientific perspective prevailing at the time from which nature was viewed as steady-state and balanced. Phenomena that shifted this balance were thought of as disturbances **to** the system from which it would recover if left alone. Inconsistencies between research results and a static view of nature have been the impetus for shifting ecologists' concept of disturbance. Widening acceptance of natural disturbance as an important structuring process is evidenced in the mid-1980's (Pickett and White 1985). It is well known that occurrence of some species in the landscape is dependent upon a particular successional habitat or disturbance regime; development of a specific community structure has also been linked to characteristics of the disturbance regime (Menge and Sutherland 1987); and ecosystems are thought to exhibit a range of states in response to natural disturbance. Today, ecosystems are considered to be dynamic and disturbance is a normal and often necessary part of system function where variation occurs at all scales - from minutes to millennia (Botkin 1990).

The treatment of natural disturbance in the NFMA and the regulations is illustrative of their origins in the steady-state view of nature. Natural disturbance is only mentioned with regard to its negative effects on forest resources. The need to maintain and protect those aspects of disturbance essential to ecosystem function are not cited and no direction is given on how this might be accomplished.

Understanding the natural disturbance regime and how it has been altered by land management is important for developing strategies that maintain means and variation of system attributes within ranges exhibited by their relatively unimpacted counterparts. The disturbance regime as characterized by the type (fire, floods, insect outbreaks, wind, volcanoes, avalanches, and earthquakes), frequency, magnitude, duration, timing, and predictability of disturbance within a watershed influences the processes delivering and transporting sediment, wood, and water to and within the stream channel. Since habitat structure is determined by these processes, heterogeneous habitat conditions should be expected - throughout a stream channel in relation to the time since last disturbance and between stream systems that might differ in disturbance regimes. Disturbance caused by management in forested montane landscapes differs from the natural regime in several ways that include changing the type of disturbance, reducing the amount of wood delivered to stream channels, shortening the interval between disturbance events, disrupting the hydrologic and sediment regimes with road building, and altering the spatial distribution and size of landscape patches. There has been a reduction in the overall quality of habitat, homogenization of conditions within streams, disconnections between areas critical to various life history stages, and elimination of refugia critical to sustain metapopulations of organisms such as various salmon and trout species (Reeves et al. 1996).

Since the NFMA is basically silent on the issue of disturbance, there is much latitude that allows planning to incorporate disturbance or not. The Draft Interior Columbia Ecosystem Management Plan (ICBEMP) is an example of a management plan built around mimicking natural disturbance processes. The primary handicap in disturbance-based management is the lack of metrics used for determining success. Information on the range of natural variability of ecosystem structures and processes has been examined as a means for assessing ecosystem health (Swanson et al. 1994; Bourgeron and Jensen 1994; Penelope et al. 1994). Although there is an intuitive appeal for using the Range of Natural Variability (RNV) to guide management, there has been very little examination of the approaches' contribution. Most energy has been directed at defining the RNV and using it to design management plans (see Jensen and Bourgeron 1994 for examples) and monitoring strategies. Technical difficulties in establishing the actual RNV have been acknowledged. These problems may be particularly acute in areas that are currently degraded and for which few clues remain to decipher the RNV. The RNV for in-channel stream habitat features (e.g., pools as habitat patches, large wood as structural elements) is used to define desired future conditions for maintaining and restoring stream systems (USFS and USDI 1995). This application has received criticisms, among these, the apparent disconnect between the physically established RNV and physiological tolerances for aquatic species (Rhodes et al.

1994). Long-term/large-scale research is necessary to assess the utility of the RNV in attaining ecosystem management goals. Since this approach is relatively new, no studies of this type have been completed.

D. Diversity - Maintenance of diversity is crucial to aquatic ecosystem function and persistence. The NFMA directed guidelines be developed for land management plans to achieve the goal of providing "for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives..." It makes little further mention of how diversity might be defined or assessed.

Substance for meeting the diversity clause is found in the Regulations. The most specific direction is given at 36 CFR 219.19, 219.26, and 219.27 for minimum requirements to guide the development, analysis, approval, implementation, monitoring, and evaluation of forest plans relative to diversity. The primary means for protecting diversity is to ensure that "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area. For planning purposes, a viable population shall be regarded as one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area. In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area (36 CFR 219.19)." This definition and discussion of viability is consistent with general understanding in conservation biology and reflects specific knowledge of aquatic ecosystem structure and function, particularly the role metapopulation may play in the maintenance of diversity and persistence of many species including salmon and trout in dynamic stream environments (Reeves et al. 1996).

The Management Indicator Species is the tool prescribed to plan for and assess viability. Implementation of this concept has been justifiably criticized - the use of a single species to represent an entire ecosystem garners little scientific support. However, the regulation, as written, is congruous with recent scientific thinking on management indicators, allowing them to be drawn from a wide range of plant and animal species which may include keystone species, umbrella species, populations of sensitive species, species assemblages, and functional groups. The Aquatic Conservation Strategy of the Northwest Forest Plan employed such an approach in that it was designed to meet the habitat needs of salmon and trout. Habitat of sufficient quantity and quality to support this group of fish was thought indicative of a healthy, functioning ecosystem capable of supporting most other aquatic organisms.

Assessment of species viability, the probability that a population will persist for a specified period of time across its range despite normal fluctuations in demographic and environmental conditions (Noss and Cooperrider 1994), has become a routine component of planning, especially at large scales (FEMAT 1993, Draft ICBEMP 1996). Controversy may exist about where to set levels of "probability" or the "specified period", however, this may more likely be a socio/political debate than one of science. The logic, significance, and efficiency has been questioned of attempting to assess viability for all animal and plant species thought to occur in a planning area. Although this approach as used in the FEMAT report (1993) for the Northwest Forest Plan has been ruled sufficient to meet the law, it has not yet been deemed necessary (SAS v. Lyons No. C92-479WD December 21, 1994). Since nothing in the regulations require viability be assessed for such a broad array of species, how future viability assessments are conducted appears to remain within the agency's discretion. Viability assessments for anadromous salmonids in the FEMAT report (1993) demonstrate a reasonable interpretation of the clause that was found by the court to meet the intent of the NFMA. Factors outside the control of the agency were recognized as affecting population viability (e.g. ocean harvest, dams, hatcheries, habitat on non-federal lands), consequently, thus only the likelihood was assessed that an option would provide spawning and rearing habitat sufficient to maintain viable populations. For non-migratory indicators, resident on federal lands, assessment of viability based on both habitat and population information is scientifically supportable.

E. Inventory and Monitoring:

The NFMA specified that guidelines would be developed to "provide for obtaining inventory data on the various renewable resources, and soil and water..." It does not, however, require guidelines be developed for monitoring or that a monitoring plan be a component of land management plans. In contrast, the regulations are very specific about inventory and monitoring, providing direction that a monitoring plan be a component of Forest Plans and what the monitoring plan should contain for evaluating compliance with standards and guidelines and attainment of objectives. Given these requirements for inventory and monitoring, can the questions be addressed of how well has the NFMA protected aquatic systems on National Forest

System lands and how well is it likely to do so in the future?

Trend data over the years of NFMA implementation would be necessary to answer the first question. Baseline information that systematically documents aquatic and riparian conditions across National Forest system land prior to the NFMA is unavailable. For some attributes, in some areas of the country, and over some periods, baseline inventory data may exist. For example, the Bureau of Fisheries database, collected between 1934 and 1945, describes stream habitat conditions in the Columbia River Basin. Although, this data set is invaluable for comparing current conditions of pool habitat and stream substrate with those prior to intensive management on National Forest system lands, it cannot be used to assess the effectiveness of the NFMA over the past 20 years. For this same region, aerial photos from the 1970's are available which could be assembled and used to evaluate trends in riparian conditions.

Another less definitive way to address this question is to compare current conditions on National Forest System lands with those under other ownerships. Again for some areas of the country, this may be possible, but a statistically rigorous nation-wide evaluation has not been undertaken. The Forest Service has made a national commitment to inventory stream habitat. Unfortunately, such data may not have been routinely collected on non-system lands and little coordination between agencies has occurred. Unprecedented efforts undertaken in preparing the ICBEMP and implementing the Northwest Forest Plan are examples of state and federal agencies working together to compile stream habitat information into a common database. Decisions about where to collect this information were not generally based on a probability sampling design that allows statistically valid regional comparisons. Such shortcomings are now being recognized and addressed. Although, the agency is currently limited in the scope of possible evaluations for current stream habitat conditions in the northwest, it is poised to make these determinations within the next year. A stream inventory baseline is being established for this region against which future implementation of the NFMA may be judged, yet riparian conditions will remain without a basis for comparison.

It is important to recognize that the variables contained in these stream inventories are reflective of habitat elements considered important to fish and other aquatic biota, however, these inchannel variables may not be sufficiently sensitive for the early detection of cumulative land use impacts. By the time a response is expressed in the channel, significant damage may have already occurred. Some upslope metrics (e.g., equivalent roaded or clearcut area) are available, but their use is not universally accepted. Better understanding of relationships between inchannel and upslope conditions may yield improved upslope thresholds that enable early corrective action. These efforts have been hampered by the lack of watershed data of adequate resolution. For example, digital elevation models that are widely available have 90 meter contour intervals, a resolution that is much too coarse for use in landslide modeling, watershed classification, or stream delineation. Consequently, current stream GIS data layers are usually inaccurate and may contain only a small fraction of existing channels. This may result in over estimates for predictions of available timber.

IV. Conclusions:

A. Considerations that advance aquatic ecosystem protection include:

1. Management decisions that have the greatest opportunity to foster conservation of aquatic resources are those made within the context of higher level analysis and plans for ecologically relevant units, such as watersheds and river basins.

2. Management that incorporates an understanding of connectivity, is tailored to a particular watershed, and considers conditions on all lands within its boundaries regardless of ownership has less potential for adverse individual or cumulative effects to aquatic habitat and biota and the greatest likelihood of sustaining aquatic resources.

3. Management that recognizes and preserves elements of the natural regime such as timing, intensity, extent, and type of disturbance contributes to conservation of aquatic resources.

4. Management directed at conserving aquatic ecosystem function may efficiently and effectively preserve a broader array of species than aggregating strategies aimed at individual species. If such an approach is to sustain species of salmon and trout, ecosystems must be functioning adequately to furnish habitat of sufficient quality and quantity to support well connected fish populations or stocks throughout their range. This recognizes that ecosystems are often more complex than we can comprehend, thus it may be necessary to rely on functional indicators (i.e., metapopulations, species, functional groups, structural attributes, communities) that are chosen based on scientific knowledge of their sensitivity to human activities and their role in the ecosystem.

5. Outcome-based plans that are coupled with specific criteria for judging success may be the most adaptable to changing understanding and incorporating scientific advances. However, inventory data adequate to develop such plans is often lacking and current monitoring may not

yield results that are sufficiently sensitive to allow timely corrective actions.

B. The NFMA actually provides very little guidance for protecting aquatic resources, deferring any prescriptive language to be crafted in the regulations. To the benefit of those that develop, implement, and evaluate National Forest land management plans, the regulations do offer specific direction for issues of diversity, monitoring, and multi-scale planning. Although, the boundaries defined for multi-scale planning are not coincident with hydrologic boundaries, nothing in the law or regulations prohibits using ecologically relevant boundaries for analysis and planning and subsequently aggregating such units to plan for current administrative units. The regulations basically restate language in the NFMA for water resources and offer less guidance for protecting natural disturbance regimes. While this lack of direction has resulted in inconsistent and often ineffective protection of aquatic resources, it also allows the flexibility for accommodating scientific advances into management. If the NFMA and the regulations are not modified to incorporate specific direction that reflects current understanding of aquatic systems and the potential for land management impacts to them, then through the latitude granted by these instruments, aquatic system protection may be attained. This is evidenced by the ability, under the current legal framework, to develop scientifically credible regional aquatic conservation strategies such as that contained in the Northwest Forest Plan.

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