United States
Department of
Agriculture

Forest Service

**Northeastern Forest
Experiment Station**

General Technical
Report NE-200

Status of and Attitudes Toward Aquatic Macroinvertebrate Monitoring on National Forests and Districts of the Bureau of Land Management

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Abstract

A survey was mailed to all forests in the USDA Forest Service's National Forest System (NFS) and to all Districts of the Bureau of Land Management (BLM) to determine the status of and attitudes toward aquatic macroinvertebrate monitoring (AMM). The overall survey response rate was 93 percent. Sixty-five percent of the respondents reported that they conducted AMM. There was considerable variation among regions. The median annual AMM budget was $2,000 for both NFS and BLM respondents with AMM programs. An AMM method developed in NFS Region 4 was used most frequently on National Forests and BLM Districts. Most respondents used a university, private, or, most frequently, Federal laboratory to process samples and analyze data. Respondents indicated that the product they received was superior to what they could produce, but that the turnaround time was too long. AMM data were collected mostly for use as baseline data or for impact assessment. Respondents stated that sensitivity to impacts is a major strength of AMM, but that a lack of support for AMM at higher administrative levels is a major weakness. Sixty-two percent of the NFS respondents and 82 percent of the BLM respondents indicated that AMM data had not influenced management decisions on their forest or district. Recommendations are made for improving AMM on NFS and BLM lands.

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Manuscript received for publication 29 November 1994

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June 1995

Introduction

There is a legal and philosophical basis for monitoring aquatic resources on lands administered by the USDA Forest Service's National Forest System (NFS) and the USDI Bureau of Land Management (BLM) (herein referred to collectively as public lands). The National Forest Management Act of 1976 requires monitoring within the context of each NFS Forest Plan. For example, "Monitoring and evaluation requirements will provide a periodic determination and evaluation of the effects of management practices" (36 CFR 219.11). How monitoring is incorporated in forest plans varies among forests.

Ecosystem management is the philosophical framework for managing all National Forests. An important component of ecosystem management is adaptive management, wherein land management actions are considered experiments subject to modification[1] (Noss and Cooperrider 1994). As stated by Unger,[2] "... a key element of ecosystem management is a consistent monitoring effort and evaluation of management outcomes and, where necessary, adapting our management to incorporate new information from the monitoring...." With an increased emphasis on tracking the effects of management actions on desired future conditions, monitoring, including the use of aquatic macroinvertebrates as indicators of environmental conditions (aquatic macroinvertebrate monitoring, AMM), may have an expanding role in public land management. The National Monitoring and Evaluation Strategy for the Forest Service (USDA For. Serv. 1993) identified reasons why current NFS monitoring practices are inadequate (see also Noss and Cooperrider 1994), and provided recommendations for implementing the National Strategy, primarily through Washington Office and Regional Office support and direction. The Strategy does not specifically address AMM, nor is it addressed to personnel conducting monitoring, and there has been no compilation of AMM techniques and applications currently in use on National Forests or BLM-administered lands. Prior to this study, attitudes toward AMM by land managers were unknown. Before AMM can be made more effective on NFS and BLM lands, the current status of aquatic macroinvertebrate monitoring must be assessed.

The objectives of this study were to: 1) determine the extent to which AMM is conducted on NFS and BLM lands, 2) identify aquatic sampling protocols used on these lands, 3) identify AMM program objectives and data applications, and 4) examine attitudes of public land managers toward AMM. To meet these objectives, a survey of AMM on NFS and BLM lands was conducted. This report summarizes the findings of the survey, identifies potential shortcomings of current AMM applications, and offers recommendations for enhancing the effectiveness of AMM as practiced on public lands. We intend that this report support and expand on the National Monitoring and Evaluation Strategy (USDA For. Serv. 1993). We provide few details on the design and implementation of AMM programs; instead, the reader is referred to Dissmeyer (1994).

[1] Thomas, J.W. 1994. This time, our moment in history. Title of address by Chief of the USDA Forest Service at the Forest Service Leadership Meeting, June 20-23, Houston, TX.
[2] Unger, D.G. 1993. Concerning Forest Service ecosystem management strategies. Statement before U.S. Senate Subcommittee on Agricultural Research, Conservation, Forestry and General Legislation, November 9, Washington, DC.

Methods

The individual National Forests and BLM Districts were the sampling units for this study. A questionnaire consisting of 43 questions was mailed to each USDA Forest Service Forest Supervisor and BLM District Manager with instructions to forward the questionnaire to the person responsible for implementing AMM, or if no AMM program exists, to the person most qualified to respond to questions pertaining to how AMM might be included in land management activities. We defined AMM in the questionnaire as "the repeated or occasional collection and analysis of macroinvertebrates from aquatic habitats for the purpose of baseline studies, impact assessment, compliance, or other purposes."

Questions addressed five subject areas: respondent affiliation (8 questions); status, coordination, and funding of AMM (6 questions); methodology (18 questions); integration of AMM programs and data with other agencies and sources of data (3 questions); and applications of and attitudes toward AMM (8 questions). The questionnaire required about 30 minutes to complete. Each questionnaire was given a unique number so that survey responses could be tracked.

In the affiliation section, respondents were asked their name, job title, and length of time with their agency. In the status, coordination, and funding section, respondents were asked if their forest or district has conducted AMM, for how long, the number of personnel involved, and the annual estimated AMM budget. In the methodology section, respondents were asked if they use a formal methodology, and how they collect and process their samples. In the integration section, respondents were asked how and with whom AMM data are integrated and shared. In the applications and attitudes section, respondents were asked why they collect aquatic macroinvertebrates, how the data are used, and their opinion of AMM. Respondents also were given the opportunity to identify preferred training opportunities and provide comments.

In all, 179 questionnaires (NFS = 123, BLM = 56) were mailed in March 1994. Approximately 6 weeks later, questionnaires were remailed to nonrespondents. Six weeks after the second mailing, questionnaires were sent to nonrespondents via certified mail. The response rate was 94 percent for National Forests and 93 percent for BLM Districts (NFS = 115, BLM = 52). Responses were analyzed separately for NFS and BLM respondents with and without AMM programs. For some analysis, BLM Districts were assigned to "regions" equivalent to NFS Regions based on the address of the BLM district headquarters.

In this report, "monitoring" is synonymous with "effectiveness monitoring" (Noss and Cooperrider 1994), which is the process of determining if an activity achieved the stated goal

or objective of not degrading an aquatic ecosystem. Thus, effectiveness monitoring encompasses both effects monitoring (monitoring for the effect of a management action) and baseline monitoring (monitoring for longer term changes associated with human activity). Baseline monitoring often is the first step in effectiveness monitoring.

Results and Discussion

Respondent Affiliation

The mean agency tenure was 11.6 years (Table 1, combined mean for NFS and BLM respondents). Sixty percent of the respondents were fisheries biologists; others were divided equally among hydrologists, wildlife biologists, and "other." More NFS respondents were fisheries biologists (67 percent) than were BLM respondents (44 percent). More NFS respondents were hydrologists (16 percent) than were BLM respondents (8 percent); more BLM respondents were wildlife biologists (37 percent) than were NFS respondents (3 percent).

Status of Monitoring

About 65 percent of the respondents (NFS = 67, BLM = 61, Table 2) collect aquatic macroinvertebrates for monitoring purposes on their forest or district. Of the 35 percent who indicated they do not collect macroinvertebrates, 7 percent indicated via written comment that they plan to initiate such activities soon. Among NFS regions, "current" status (currently conduct AMM) was highest in Regions 2, 4, and 6 and lowest in Regions 1, 5, and 10 (Table 2). Among BLM "regions" (based on NFS region boundaries), "current" status was highest in Region 6 (100 percent); AMM was not conducted in Regions 5 and 9.

Table 1.—Affiliation, agency tenure, and position of respondents

Affiliation	Number of responses	Number of years	Fisheries biologist	Hydrologist	Wildlife biologist	Other
			Percent			
NFS	115	11.3 (7.1)[a]	67.0	15.7	2.6	14.8
BLM	52	12.3 (7.7)	44.2	7.7	36.5	11.5
All	167	11.6 (7.3)	59.9	13.2	13.2	13.8

[a]SD in parenthesis.

Table 2.—Macroinvertebrate monitoring on National Forests and BLM Districts, by region

Monitoring status	Respondents in Region[a]									All respondents
	1	2	3	4	5	6	8	9	10	
	Percent									*Percent*
NATIONAL FORESTS										
Current	46.2	83.3	70.0	93.7	46.7	73.2	66.7	61.5	50.0	67.2
None	53.8	8.3	30.0	6.2	40.0	27.8	13.3	30.8	25.0	25.9
Planned	0.0	8.6	0.0	0.0	13.0	0.0	20.0	7.7	25.0	6.9
n	13.0	12.0	10.0	16.0	15.0	18.0	15.0	13.0	4.0	
BLM DISTRICTS[a]										
Current	60.0	50.0	66.7	68.7	0.0	100.0	na[b]	0.0	25.0	61.1
None	20.0	37.5	33.3	18.8	100.0	16.7	na	100.0	75.0	31.5
Planned	20.0	12.5	0.0	12.5	0.0	0.0	na	0.0	0.0	7.4
n	5.0	8.0	6.0	16.0	3.0	10.0	na	2.0	4.0	

[a]Districts assigned to NFS regions.
[b]Not applicable; there are no BLM Districts in NFS Region 8.

About half of the AMM programs (NFS = 46 percent, BLM = 54 percent, Table 3) had been in existence for five years or more. About a quarter of the respondents (NFS = 24.2 percent, BLM = 30.3 percent) indicated they had begun AMM within the last 2 years (Table 3).

Of the respondents who reported conducting AMM, more than 97 percent sampled stream habitats (Table 4). Of the total sampling effort, most was concentrated on streams (NFS = 92 percent, BLM = 98 percent). The remaining samples were collected in lakes or wetlands.

Table 3.—Number of years of monitoring using aquatic macroinvertebrates; values are percentages of responses from respondents that conduct monitoring

Years of data collection (no.)	Respondents	
	Number	Percent
	NFS	
<1	3	3.8
1-2	16	20.5
3-5	23	29.5
>5	36	46.2
	BLM	
<1	1	3.0
1-2	9	27.3
3-5	5	15.2
>5	18	54.5

Budget and Staffing

The mean staffing level for AMM responsibilities for National Forests and BLM District with AMM programs was about 2.0 permanent and 1.0 temporary employees, respectively (Table 5, combined totals).

The mean annual AMM budget for forests or districts with AMM programs was about 2 times higher for National Forests than for BLM Districts ($5,134 versus $2,617). The median annual budget was $2,000 for both agencies.

Monitoring Methodology

"Standard" monitoring methodologies were used by about 75 percent of the respondents (Table 6). Of these, the NFS Region 4 method, also known as the Biotic Condition Index Protocol (Winget and Mangum 1979), was used most frequently by the forests (55 percent) and districts (64 percent). The Region 4 method was used most frequently in NFS Regions 1, 3, 4, 5, and 6, and least often in NFS Regions 8 and 9. State and U.S. Environmental Protection Agency (EPA) methods were used most frequently in NFS Regions 8 and 9. The NFS Region 4 method was used most frequently throughout the BLM.

Table 4.—Types of aquatic habitat monitored using macroinvertebrates on NFS and BLM lands; percent is the percent of respondents who monitor that habitat type; effort is the mean percent of total effort spent monitoring that habitat type

Agency	Item	Streams	Lakes	Wetlands
NFS	Frequency	75	18	4
	Percent	97.4	23.7	5.5
	n	77	77	78
	Effort (%)	92.0 (20.2)[a]	7.4 (19.7)	0.5 (2.4)
BLM	Frequency	33	2	6
	Percent	100.0	6.1	18.2
	n	33	33	33
	Effort (%)	97.9 (4.7)	0.5 (1.9)	1.7 (4.3)

[a] SD in parenthesis.

Table 5.—Staffing and annual budget for aquatic macroinvertebrate monitoring on NFS and BLM lands

NFS employees who monitor		NFS budget[a]		BLM employees who monitor		BLM budget[b]	
Permanent	Temporary	Mean	Median	Permanent	Temporary	Mean	Median
Number		*Dollars*		*Number*		*Dollars*	
2.3 (2.0)[c]	1.1 (1.4)	5,134.00	2,000.00	1.8 (1.3)	0.6 (0.9)	2,617.00	2,000.00

[a] Range = 0 to $30,000.
[b] Range = 0 to $10,000.
[c] SD in parenthesis

Table 6.—Percentages of NFS and BLM respondents who use aquatic macroinvertebrate monitoring, by region and method used most often

Method	Respondents in Region: 1	2	3	4	5	6	8	9	10	All
					NFS					
Forest Service Region 4	83.3	50.0	85.7	93.3	66.7	41.7	20.0	0.0	50.0	55.3
EPA Rapid Bioassessment	33.3	10.0	0.0	0.0	16.7	16.7	40.0	25.0	0.0	15.8
Private consultant	33.3	10.0	14.3	20.0	0.0	16.7	10.0	0.0	0.0	13.2
State	33.3	0.0	0.0	6.7	0.0	8.3	10.0	62.5	0.0	13.2
NWQA[a]	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	1.3
Own	16.7	50.0	14.3	0.0	50.0	33.3	40.0	25.0	50.0	27.6
n	6.0	10.0	7.0	15.0	6.0	12.0	10.0	8.0	2.0	76.0
					BLM					
Forest Service Region 4	33.3	75.0	75.0	63.6	na	60.0	na[b]	na	100.0	63.6
EPA Rapid Bioassessment	33.3	0.0	25.0	0.0	na	30.0	na	na	0.0	15.2
Private consultant	0.0	0.0	0.0	9.1	na	30.0	na	na	0.0	12.2
State	0.0	0.0	0.0	9.1	na	0.0	na	na	0.0	3.0
NWQA[a]	0.0	0.0	0.0	0.0	na	0.0	na	na	0.0	0.0
Own	66.7	25.0	25.0	27.3	na	10.0	na	na	0.0	24.2
n	3.0	4.0	4.0	11.0	na	10.0	na	na	1.0	33.0

[a]National Water Quality Assessment, U.S. Geological Survey.
[b]Not applicable; there are no BLM Districts in NFS Region 8.

NFS and BLM respondents most frequently used a Surber sampler with a mesh size between 0.25 and 0.5 mm (usually 0.28 mm) to collect three samples per site from riffle habitats (Table 7). This is the protocol recommended in the NFS Region 4 method.

Of the NFS and BLM respondents with AMM programs, 88 percent used a macroinvertebrate processing laboratory rather than their own facilities or personnel. Together, the Forest Service's Aquatic Ecosystem Laboratory in Provo, Utah, and the BLM Aquatic Ecosystem Laboratory in Logan, Utah, accounted for 64 percent of the NFS respondents and 90 percent of the BLM respondents (Table 8) who did not process their own samples.

Respondents were asked why they chose a particular laboratory using a score of 1 (strongly agree) to 5 (strongly disagree) for the following potential reasons (i.e., reasons for selecting one lab over another lab or doing it themselves): 1) cost savings, 2) superior quality of results, 3) more detailed analysis of results, and 4) more timely results (Table 9). For both the NFS and BLM, respondents agreed most strongly, relative to other reasons (combined mean score = 2.1), that the use of a lab resulted in more detailed analysis of results. Respondents disagreed most strongly that the use of a lab resulted in more timely results (combined mean score = 3.1). A two-sample Wilcoxson test showed no difference in mean opinion scores between NFS and BLM respondents. From the way in which the question was worded, it was not clear whether respondents interpreted it as What is the advantage of the laboratory you have chosen over other laboratories? or What is the advantage of the laboratory you have chosen over doing it yourself? Since most respondents reported having used only one laboratory, we suspect the latter interpretation predominated.

AMM data were well integrated with other kinds of monitoring data collected by NFS and BLM land managers. Overall, 64 to 85 percent of the respondents indicated that AMM data were integrated with data on fisheries, physical habitat, and/or water quality (Table 10). Apparently, AMM is seldom used alone for monitoring aquatic resources. More respondents coordinated AMM activities with state agencies than with other agencies (Table 10). Coordination most often took the form of exchanging monitoring results (48 percent) or informing the other agency where AMM data were being collected (47 percent).

Purposes and Objectives of Monitoring

Collection of baseline data was the reason cited most often for collecting AMM (ranked first by 65 percent of all respondents who collect baseline data and ranked highest overall, Table 11). This was followed by impact assessment (ranked first by 40 percent of all respondents who used AMM for impact assessment, and second overall). Use in trend studies and compliance with Federal laws also were important to NFS and BLM respondents, respectively.

Table 7.—Sampling protocols used most often in NFS and BLM monitoring programs

Item	NFS respondents		BLM respondents	
	Number	Percent	Number	Percent
Sampler				
Surber	54	71.1	30	90.9
Kick net	22	29.7	8	25.0
Hess	9	12.0	0	0.0
Artificial Substrate	4	5.4	1	3.1
Seine	2	2.7	2	6.2
Other[a]	12	16.2	2	6.2
Net Mesh Size				
<0.25 mm	14	26.4	5	18.5
0.25 to 0.5 mm	31	58.5	21	77.8
0.5 to 1.0 mm	7	13.2	1	3.7
>1.0 mm	1	1.9	0	0.0
Stream Habitat Sampled				
Riffles only	45	60.8	25	75.8
Riffles and pools	13	17.6	4	12.1
Riffles, pools, CPOM[b]	14	18.9	4	12.1
Other[c]	2	2.7	0	0.0
Season				
Winter	5	6.6	5	15.5
Spring	34	44.7	16	48.5
Summer	53	69.7	26	78.8
Fall	52	68.4	22	66.7

[a]NFS: "t-walk" (examination of 10 cobbles), Ekman dredge, plankton haul net, zooplankton vertical haul net, Wisconsin planton net, diving, electrofishing, "cobbles plus detritus"; BLM: Ekman dredge.
[b]Coarse particulate organic matter.
[c]Composite samples and stream margin samples.

Table 8.—NFS and BLM respondents who use macroinvertebrate processing facilities other than their own for analysis of aquatic samples, by type of facility used

Facility	NFS respondents		BLM respondents	
	Number	Percent	Number	Percent
Forest Service at Provo, UT	29	49.2	9	31.0
Bureau of Land Management at Logan, UT	9	15.3	17	58.6
Private consultant	8	13.6	3	10.3
State laboratory	4	6.8	0	0.0
University	9	15.3	0	0.0

Table 9.—Opinion scores[a] of NFS and BLM respondents for services provided by outside macroinvertebrate processing facilities

Facility provides:	NFS respondents		BLM respondents	
	Number	Score	Number	Score
Cost savings	59	2.6 (1.0)[b]	26	2.4 (1.0)
Superior quality results	58	2.3 (0.9)	26	2.1 (1.0)
More detailed analysis	59	2.2 (1.0)	26	2.0 (0.9)
More timely results	59	3.1 (1.2)	27	3.0 (1.4)

[a]Based on scale of 1 (strongly agree) to 5 (strongly disagree).
[b]SD in parenthesis.

Table 10.—NFS and BLM respondents who integrate other data with their macroinvertebrate monitoring data and who coordinate monitoring activities with other agencies, Forests or Districts, by type of data and agency/affiliation

	NFS respondents		BLM respondents	
Item	Number	Percent	Number	Percent
Type of Data				
Fisheries	51	66.7	25	75.8
Physical habitat	56	73.1	21	63.6
Water quality	58	74.4	28	84.8
Other	8	10.3	4	12.1
Agency/Affiliation				
EPA	5	6.4	2	6.1
NFS	8	10.3	13	39.4
BLM	3	3.8	5	15.2
State	7	47.4	15	45.5
Other	8	10.3	4	30.3

Table 11.—Primary purposes for which aquatic macroinvertebrate monitoring data are collected, and their mean ranking by NFS and BLM respondents (1 = most important; 6 = least important)

Respondents	Baseline data	Impact assessment	Trend studies	Compliance	Controlled studies	Other [a]	Emergency
NFS							
Number	44	25	16	6	6	1	0
Percent	62.0	39.1	25.8	12.5	12.5	33.3	0
Mean rank (SD)	1.7 (1.2)	2.0 (1.0)	2.5 (1.3)	3.9 (1.5)	4.1 (1.6)	4.3 (3.1)	4.7 (1.4)
n	71	64	62	48	48	3	41
BLM							
Number	23	11	0	8	0	2	1
Percent	71.9	40.7	0.0	27.6	0.0	100.0	5.9
Mean rank (SD)	1.5 (0.9)	2.0 (1.0)	4.7 (1.2)	2.1 (1.0)	4.3 (1.0)	na[b]	5.3 (1.3)
n	32	27	29	17	16	2	17

[a] NFS response was "established desired future condition." BLM responses include mining reclamation and "fisheries/riparian/water quality potential."
[b] Not applicable, too few responses to calculate a mean.

Table 12.—Mean percentage of total macroinvertebrate monitoring effort on various land-management activities

	Monitoring effort	
Activity	NFS	BLM
Timber harvesting	24.1 (24.4)[a]	11.1 (21.7)
Grazing	18.1 (25.3)	51.0 (37.4)
Road building	15.5 (17.1)	6.4 (12.6)
Mining	7.7 (17.5)	12.2 (23.3)
Fire	5.9 (14.1)	3.2 (9.8)
Site preparation	2.1 (6.7)	1.9 (9.1)
Other [b]	22.6 (36.8)	14.2 (27.0)

[a] SD in parenthesis.
[b] NFS: overall land management, natural disasters, water diversions, reservoir management, recreation, human risk management, ski area, stream improvement, general habitat evaluation, watershed restoration, aquatic ecosystem health, oil and gas operations, air quality, acid precipitation, private land impacts, development of ecological units; BLM: dam operations/minimum flow issues, riparian areas, watershed stabilization structures, small hydro development, water withdrawal, hazmat spills, oil and gas development.

More of the NFS AMM monitoring (24 percent) was expended on timber harvesting than on any other land management activity (Table 12). Grazing and road building also were important activities (34 percent). Fifty-one percent of the BLM monitoring was expended on grazing management. Mining and timber harvesting also were important reasons for monitoring (23 percent). Many "other" management activities for which AMM data were used are listed in Table 12.

AMM data were used most frequently to evaluate individual management actions (61 percent of all responses, Table 13). Ranking second in frequency was entry into a long-term data base (48 percent). About 6 percent of the respondents reported that AMM data were collected but never used.

There is an apparent contradiction between the primary reason why AMM data are collected (baseline data, Table 11) and the primary use of monitoring data (evaluate management-action, Table 13). We suspect that many AMM programs have both objectives, or that the objectives are confused. If it exists, this contradiction indicates a potential problem because programs designed primarily to collect baseline data may not be configured optimally to detect management (or other disturbance) effects.

Forty-six NFS respondents (61 percent) and 33 BLM respondents (82 percent) said that the results of macroinvertebrate monitoring conducted by their office did not influence management decisions. Adaptive management of aquatic ecosystems may be the exception rather than the rule on NFS and BLM lands.

Attitudes Toward Monitoring

Respondents were asked to score AMM on the basis of six criteria: 1) whether it is a worthwhile activity; 2) its cost effectiveness; 3) the time it takes to obtain useable information; 4) accuracy/precision of results; 5) sensitivity to impacts; and 6) support for AMM at higher administrative levels. Each criterion was scored from 1 to 5 (strong advantage to strong disadvantage, Table 14).

Both NFS and BLM respondents rated highest the overall value of AMM (as a worthwhile activity) followed by sensitivity of macroinvertebrate communities to impacts (mean score of 2.0 to 2.1, Table 14). NFS respondents indicated that support at higher administrative levels (mean score = 3.4) and time required to obtain information (mean score = 3.1) were the greatest disadvantages of AMM. BLM respondents answered similarly except that the mean BLM score for administrative support (2.9) was significantly higher (more favorable) than the NFS score (3.4).

Scores also were analyzed separately for respondents with and without an AMM program. NFS respondents with an AMM program rated the overall value of AMM significantly higher (agreed that it was worth doing) than respondents with no AMM program (Table 15). NFS respondents with an AMM program indicated that lack of administrative support was less of a disadvantage than respondents with no AMM program. Across the six criteria, the value of AMM was rated higher among NFS respondents with an AMM program. BLM respondents with and without AMM programs rated AMM similarly (Table 15).

Table 13.—Uses of macroinvertebrate monitoring data (NFS, n=76, except "data are not used," n=75; BLM, n=33) for respondents with AMM programs

	NFS respondents		BLM respondents	
Monitoring data use	Number	Percent	Number	Percent
Evaluate management action	47	61.8	19	57.6
Entered into long-term data-base	38	50.0	14	42.4
Incorporated into Forest/Resource Area Plan	18	23.7	13	39.4
Other[a]	17	22.4	4	12.1
Not used	3	4.0	3	9.1

[a]"Other" responses include, NFS: enforcement on mining, stream health assessment, biodiversity assessment, cumulative watershed assessment, stream survey reports, general trends, "health," baseline for watershed analysis, hatchery operations, municipal runoff, monitor class 1 wilderness, define desired future conditions, NEPA documents, basis for road closure, annual project reports, profiling stream communities; BLM: evaluate reclamation, used to form opinion of health of aquatic ecosystems, used to support other data.

Table 14.—Opinion scores for attitudes on macroinvertebrate monitoring by all respondents (1 = strong advantage; 5 = strong disadvantage)

Opinion of macroinvertebrate monitoring	NFS respondents		BLM respondents	
	Number	Mean score	Number	Mean score
Worthwhile[a]	112	2.0 (0.9)[b]	53	2.1 (1.0)
Cost effective	109	2.9 (1.0)	50	2.8 (1.0)
Provides timely data	110	3.1 (1.1)	50	3.0 (1.1)
Accurate/precise results	109	2.7 (1.0)	52	2.4 (0.9)
Sensitive to impacts	111	2.1 (1.0)	53	2.0 (0.9)
Supported at higher administrative levels	112	3.4 (1.1)	51	2.9 (1.0)[c]

[a] For this statement, 1 = strongly agree; 5 = strongly disagree.
[b] SD in parenthesis.
[c] P <0.01 based on two-sample Wilcoxson test of difference.

Table 15.—Opinion scores for attitudes on macroinvertebrate monitoring by NFS and BLM respondents with and without monitoring programs (1 = strong advantage; 5 = strong disadvantage)

Opinion of macroinvertebrate monitoring	Respondents with programs		Respondents without programs	
	Number	Mean score	Number	Mean score
		NFS		
Worthwhile[a]	77	1.8 (0.8)[b]	35	2.5 (1.0)[c]
Cost effective	76	2.8 (1.0)	33	3.1 (1.1)
Provides timely data	76	3.0 (1.2)	34	3.3 (1.0)
Accurate/precise	75	2.7 (1.0)	34	2.8 (1.1)
Sensitive to impacts	76	2.0 (0.9)	35	2.3 (1.0)
Supported at higher administrative levels	77	3.2 (1.1)	35	3.7 (1.0)[d]
		BLM		
Worthwhile[a]	33	2.0 (0.9)	20	2.0 (1.0)
Cost effective	32	2.8 (1.1)	18	2.8 (1.0)
Provides timely data	33	3.2 (1.2)	17	2.6 (0.9)
Accurate/precise	33	2.3 (0.9)	19	2.6 (0.8)
Sensitive to impacts	33	2.0 (0.8)	20	2.0 (0.9)
Supported at higher administrative levels	32	2.9 (1.0)	19	2.9 (0.9)

[a] For this statement, 1 = strongly agree; 5 = strongly disagree.
[b] SD in parenthesis.
[c] P <0.01 based on two-sample Wilcoxson test of difference.
[d] P <0.1 based on two-sample Wilcoxson test of difference.

Although more than 83 percent of the respondents had received some form of AMM training (Table 10), 91 percent indicated they would like additional training opportunities (e.g., videos, workshops, and manuals), and 73 percent indicated they would attend a conference on macroinvertebrate monitoring on federal lands to exchange information on monitoring methods and applications.

Respondents' Written Comments

Many respondents provided additional written comments (see Appendix 1), which fell into eight categories:

1. Cost of AMM. Several respondents (comments 1, 7, 10, 16, 22, 31, 35, 44, 51, 53) indicated that cost effectiveness is an important criteria for AMM, or that currently they had insufficient funding to conduct AMM properly.

2. Relevance of AMM data. The relevance or suitability of AMM data for evaluating management impacts was questioned by several respondents (comments 2, 3, 9, 10, 32, 39). Monitoring fish or fish habitat often was considered more important than monitoring macroinvertebrates.

3. Time needed to process samples. Comments 3, 5, 6, 13, 17, 24, 25, and 52 refer to past problems with the turnaround for samples submitted to the NFS Laboratory at Provo, Utah. The recent (since 1992) availability of similar services through the BLM Laboratory at Logan, Utah, has greatly reduced the turnaround for the service. For example, the average time to complete analysis reports from the date a sample was received at the Logan lab in FY94 was less than 3 months compared to more than a year in the recent past (M. R. Vinson, unpub. data).

4. Acceptance of AMM. Comments 15, 16, 21, 25, 26, 41, and 42 refer to the need to better "sell" AMM to biologists and at higher administrative levels.

5. Sensitivity of AMM. Several respondents felt that natural variability was so great that current AMM methods may be unreliable or insensitive to impacts (comments 2, 3, 8, 18, 23, 28, 43).

6. Region 4 and EPA methods. Six respondents had concerns or opinions about the Region 4 or EPA methods (comments 6, 8, 14, 23, 27, 44).

7. Guidance and training. Many respondents (comments 1, 4, 5, 16,19, 21, 24, 25, 37, 46, 47, 48, 49, 50) indicated that they needed more assistance with AMM program direction and training, or that national standards would be useful.

8. Baseline and impact assessment monitoring. The need for an AMM method or methods that can accommodate both baseline or trend monitoring as well as impact assessment was mentioned or implied by a number of respondents (comments 11, 13, 20, 27, 35, 38).

Key Conclusions and Recommendations

1. Interest in AMM is high. The return rate for the mailed survey exceeded 93 percent, and many respondents added comments in writing or by electronic message. Technology transfer on AMM that is extended to NFS or BLM district personnel would be welcomed in most instances.

2. Between 60 and 70 percent of all National Forests and BLM Districts currently conduct some form of aquatic macroinvertebrate monitoring. There is considerable variation among regions in the level of AMM activity.

3. The mean annual budget for AMM, as estimated by respondents, was about $5,100 for National Forests and $2,600 for BLM Districts. The median budget was $2,000 for both agencies.

4. The NFS Region 4 methodology was used most frequently on National Forests and BLM Districts, especially in the West.

5. Most Forests and Districts submitted their samples to a laboratory for processing and analysis, most frequently to the Forest Service's National Aquatic Ecosystem Laboratory or the BLM National Aquatic Ecosystem Laboratory. Respondents stated that an advantage of these labs was that they provide more detailed analysis than the respondents could achieve. A disadvantage cited was the long turnaround for results.

6. Baseline data collection and impact assessment were the primary reasons why AMM data were collected.

7. Timber harvest (NFS) and grazing (BLM) were the management activities monitored most frequently.

8. Respondents with an AMM program generally had a more favorable opinion of AMM than respondents with no AMM program.

9. A strength of AMM cited by respondents was the sensitivity of macroinvertebrates to impacts. A weakness cited was the poor support for AMM at higher administrative levels.

10. Sixty-one percent of the NFS respondents and 82 percent of the BLM respondents with monitoring programs stated that the results of macroinvertebrate monitoring conducted by their office did not influence management decisions. This finding suggests that much, if not most, AMM is not tied properly to a forest or district management plan; otherwise AMM results would, by the definition of effectiveness monitoring, indicate a need for change in practices, or would confirm the suitability/effectiveness of existing practices—both of which influence management decisions. Unplanned or unprogrammatic AMM activities probably are a waste of time and money.

Although we agree with many of the respondents that AMM is not valued equally at all administrative levels (Key Conclusions 9 and 10), we also suspect that if greater

emphasis were placed on defining objectives, sampling design, and the end use of the data. AMM might become more influential in management decisions. It may be that AMM data are not often used in decisionmaking (less than 40 percent of forests or districts) because they are misleading, unreliable, or irrelevant compared to other sources of data such as fisheries, sediment, habitat, forage, and water-quality surveys. However, the use of AMM has increased since the recognition many years ago (Cairnes and Pratt 1993) that in some instances and for some purposes, macroinvertebrate community data are superior to these other sources of information (see reviews in Rosenberg and Resh 1993). An objective consideration of when and where AMM is appropriate, and its proper well-planned application where appropriate are challenges facing public land managers.

We offer several recommendations for improving the effectiveness of AMM applications on public lands in both the short and long term. We believe that a combination of basic research, technology transfer, and administrative actions is needed. Some recommendations reflect the findings of this survey; others are based on our own experience and observations. Several are similar to those of the National Monitoring and Evaluation Strategy (USDA For. Serv. 1993; see also Noss and Cooperrider 1994, and USDA For. Serv. 1994).

Basic Research

Validation of NFS Region 4 methodology. To our knowledge, the NFS Region 4 method has not been validated independently or compared with other methods. Since the method probably is in use over a wider geographic area than any other single method currently in use in the United States, some experimental verification of its performance under various conditions for detecting impacts and assessing ecosystem conditions seems prudent.

National standardization. The U.S. Geological Survey (Cuffney et al. 1993; Gurtz 1994) and EPA (Plafkin et al. 1989; Klemm et al. 1990) have adopted national protocols and recommendations for AMM and other types of aquatic sampling. Because the ecosystems being sampled are no less variable than NFS and BLM aquatic ecosystems, we believe that national protocols also are feasible for NFS and BLM lands. Research or discussion directed toward developing national or agencywide methods or at least guidelines eventually would allow a comprehensive evaluation of aquatic conditions on all public lands. Dissmeyer (1994) has made progress in this regard.

Evaluate appropriateness of AMM methodologies for detecting various impacts. Respondents identified more than 20 impacts or activities for which AMM data were used. The appropriateness of the most commonly used methods as they typically are applied is largely unknown. Studies relating the effectiveness of the monitoring method (e.g., sensitivity) to management activities are needed.

Identify and address geographic information gaps. There is a lack of basic information on macroinvertebrate ecology for some regions. Several respondents from Alaska indicated that this lack of information is a deterrent to initiating AMM since metrics and data interpretations based on methods developed at lower latitudes likely would be meaningless.

Research cooperation. There have been few studies of AMM by Forest Service or BLM researchers. One reason for this is that the Forest Service and BLM scientists typically have concentrated on watershed, fisheries, and fish habitat studies rather than on macroinvertebrate-based research. Also, research ecologists and land managers often have different priorities (Hart 1994). However, if research ecologists were to avail themselves of NFS or BLM macroinvertebrate laboratories, the amount of basic research and technology transfer related to AMM might increase.

Technology Transfer

Provide guidance on program selection. As noted earlier, National Forests and BLM Districts often need two somewhat distinct types of data: long-term baseline data and shorter-term impact assessment data. Often, more than one approach to AMM is needed by managers; flexible or two-level monitoring programs best meet this need. Also, managers often need assistance in determining monitoring needs, setting objectives, and selecting appropriate methodologies.

Provide guidance with objective defining and program design. The importance of helping managers articulate monitoring goals and objectives cannot be overstated. "What seems an obvious first step, that of defining objectives of an [AMM program], needs to be considered very carefully because all other components of the monitoring plan will be dependent on the objectives. [For many monitoring schemes] the objectives are either not stated at all or are so woolly that they are meaningless" (Spellerberg 1991, cited in Noss and Cooperrider [1994]). Dissmeyer (1994) provides useful advice on monitoring program planning and design.

Many current NFS and BLM AMM programs are very unsophisticated. In most cases, more consideration to "experimental" design would improve the credibility and applicability of the results, and at little additional cost. The use of paired watersheds or other controls, stratification, and collection of covarying information (e.g., sediment, water quality data, GIS information) are options for improving AMM resolution that could be presented via technology transfer.

Reach out to higher administrative levels. The effectiveness of AMM needs to be demonstrated to NFS and BLM managers and their staffs. In helping biologists make the best case for AMM, technology transfer insures that administrators judge fairly the effectiveness and usefulness of AMM for their forest or district.

Ecosystem management. Personnel engaged in monitoring should stress to publics and colleagues that aquatic macroinvertebrates not only are a potential tool for monitoring the quality of the environment for traditional resource values such as clean water and fisheries, but also are key components of what are arguably the most important resources on much of our public land—properly functioning aquatic and riparian ecosystems. Thus, monitor-

ing aquatic macroinvertebrates is perforce a form of ecosystem management.

Administrative Action

Expand capacity of Federal monitoring laboratories. Because the two national invertebrate processing laboratories in Utah are nearly always at full capacity, the long turnaround for processing submitted samples is a continual complaint. The BLM National Aquatic Ecosystem Laboratory received 1,081 samples in FY94, all but 31 of which were from 12 western states (M.R. Vinson, unpub. data). There is no comparable Federal facility in the eastern United States. Such a facility probably would improve the quality of AMM programs on eastern and southern National Forests, and foster national consistency in AMM methods and applications.

Increase parity in AMM funding. An effort should be made to explore ways to improve parity in funding for AMM (and all other forms of monitoring) among National Forests and BLM Districts. Although we do not expect or advocate that funding for monitoring be allocated strictly on the basis of the amount of aquatic habitat, we believe that the public expects reasonably equivalent protection for the aquatic resources it owns across the United States.

Provide national leadership on aquatic monitoring including AMM. Other recommendations presented here will not be realized without acknowledgment at the highest administrative levels in the Forest Service and BLM that aquatic monitoring as currently practiced on National Forests and BLM Districts must be refined and perhaps expanded to reach its full potential.

Acknowledgment

We thank Layne Godwin, Linda Plaugher, and Rob Hood for their assistance in preparing the questionnaire used for this report, and Mary Beth Adams, Skip Echelberger, Chuck Hawkins, Jeff Kershner, and Ken Roby for reviewing the manuscript.

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Appendix I

Selected Comments of Respondents

All comments that reflect an attitude toward or a suggestion for macroinvertebrate monitoring are included. They have been edited for conciseness and clarity.

NFS, Region 1

1. If a monitoring procedure can be set up to minimize cost (or at least be cost effective), we would like to implement some level of monitoring on forest streams. The proper collection, identification, enumeration, and analysis are the main components [for which] we would need assistance and/or training.

2. I don't feel the effectiveness of macroinvertebrate sampling has been shown...we know virtually nothing about within-year and between-year interactions and population variation in invertebrate populations...We have collected invertebrate data on one district. While the invertebrate data says things are not bad, the fish habitat is down the tubes. There is a danger in using invertebrate data to establish ecosystem health. We have discontinued monitoring of invertebrates.

3. I think macroinvertebrates are the way to go for [certain] water quality problems—mine drainage for instance. We don't deal with much of that. Most of our watershed impacts deal with stream function, or change in the physical attributes of the channel...caused by logging...grazing...and placer mining. In these cases, we're better off monitoring the direct results of the impact rather than a surrogate parameter such as the macroinvertebrates. Where we have true water quality impacts, I think the bugs are one of the best indicators. However...the long turnaround time [for laboratory identification and data analysis] is discouraging.

4. We need some clear and concise direction on what the standard should be, and what the role/priority macroinvertebrates should be in the overall monitoring and inventory for aquatic ecosystems.

5. I think macroinvertebrate sampling would provide valuable information. My main concerns are the time it would take [to process samples]...and our current personnel shortages...A good collecting protocol, funding...and a lab that could analyze samples would be a good first step for widespread macroinvertebrate sampling implementation.

6. Macroinvertebrate monitoring can be very useful when the following conditions are met: 1) appropriate design, 2) appropriate methods, 3) sampling consistency, and 4) results are obtained in a reasonable time frame. The USFS lab's turnaround time of 2-3 years is unacceptable. [The USFS lab's] analysis protocol and metrics...should be flexible to meet site-specific design criteria. Current analysis techniques and turnaround time prohibit me from taking advantage of the facility...I have lost support from many cooperators because of this problem.

7. There are specific circumstances where [macroinvertebrate monitoring] is a very worthwhile activity and very cost effective, while in other instances, the chance of detecting anything is remote.

8. I have strong personal reservations about [Region 4's] BCI index and assumptions. I am personally frustrated by lack of best scientific advice on indicator species...statistical analysis of results...community-level effects, and the [questionable] utility of the procedure in ultrapure water conditions.

9. There are other physical parameters that can be more directly related to management impacts. We need to be able to answer questions about changes in fish habitat conditions (major public issue) before we have the luxury of monitoring invertebrates...The interpretation of monitoring results is too often ambiguous.

10. The problem with our [AMM] program is that the...funding necessary to collect enough data to produce reliable results was just not there, and I doubt that it is [elsewhere in the National Forest system]. It's going to take a lot of time, money, effort and dedicated commitment to develop macroinvertebrate monitoring programs. More direct [approaches to] assessing impacts (e.g., stream surveys and fish population estimates) may be more important.

NFS, Region 2

11. [Our Forest] is in the process of establishing monitoring protocols for watersheds. We hope that this monitoring will be geared to site-specific (impact) monitoring and long-term trend monitoring. This protocol will be built within our revised forest plan.

NFS, Region 3

12. The monitoring job is huge [on this Forest], and macroinvertebrate monitoring just doesn't rank very high in priority.

13. Additional baseline inventory is needed Forest-wide rather than reacting to proposed activities. Funding needs to be consistent for monitoring activities. Turnaround times have been improved but we still need to have results sooner.

14. [Region 4's] BCI has the potential for use in forest health monitoring. We currently have plans to implement BCI in a Wilderness as a measure of ecosystem health.

15. [Macroinvertebrate monitoring] is not well known by specialists other than fisheries biologists and some hydrology specialists. A greater understanding and awareness of the technique and its utility in typical field applications for today's issues are needed.

16. To be useful, this activity needs to be simple...flexible, cost/time effective, applicable, understandable (to management and biologists), etc. At times it seems I'm unable to make a case [for monitoring]...Results are not immediately available and applications are often deferred to the future... I am not versed enough in species ecology to feel confident to fully interpret the data. That's where the indices help.

NFS, Region 4

17. The only downside to [macroinvertebrate] monitoring is the time it takes to get samples analyzed.

18. Statistical variation [in macroinvertebrate parameters] between samples at a site is great. Perhaps emphasis on sampling criteria such as depth, velocity, and substrate size [for] sensitive species...can be incorporated into a training exercise.

19. [I'm] interested in learning how to make better interpretations [of macroinvertebrate monitoring data].

NFS, Region 5

20. I would like to see the Forest become more involved in [macroinvertebrate monitoring]. The critical element is tying this monitoring to management impacts (stream bank stability, watershed health, water quality impacts by grazing/recreationalists).

21. I need to be shown what macroinvertebrate data will show in terms of monitoring recovery of riparian conditions and in assessing overall riparian conditions.

22. I would like to see macroinvertebrate sampling integrated into our regular program of work for monitoring; however, we currently lack the resources (staffing) to initiate such monitoring.

23. Our data base currently has data from about 200 stations on about 80 streams...The EPA protocols appear not to discern the subtler impacts of timber harvest, etc. in wildland streams.

24. A comprehensive effort nationwide to indicate overall health of aquatic systems would be useful...I'd like a regional lab to process [macroinvertebrates] so we would not have to wait so long for results.

25. We need more direction on what to do with [monitoring data]. This is part of the broader need for guidance on how to develop a monitoring program that links management objectives to a plan for collection, analysis, and evaluation of results. Sorting and analysis of samples became too expensive and took over a year for results to come back from the [USFS] lab. Management didn't care enough to follow up on results, so the program was dropped for lack of any support other than my own personal interest in the program.

NFS, Region 6

26. To make [macroinvertebrate monitoring an] important part of the Forest monitoring program...it will have to be "sold" to line and [Regional Office]. I am not a very good salesman.

27. Macroinvertebrates are a useful tool and the information is useful for both establishing baseline populations and evaluating land management impacts. I have more experience using BCI methodology, but I think that other techniques might be better.

28. [Macroinvertebrate] sampling needs to take place over all seasons to assess total community response to land management impacts...I'm not convinced that macroinvertebrate monitoring by itself is a valuable assessment tool. [It] needs to be integrated with water quality and instream and riparian habitat assessments relative to the watershed condition assessment.

29. Although I don't disagree...that macroinvertebrate abundance/diversity relates to watershed impacts, I do not believe cause and effect information exists in enough detail (at least as it relates to forest management) to make it very useful to argue for management changes.

30. As I...evolve into a freshwater ecologist, the importance of invertebrate...monitoring and analysis has become obvious. We need to target training at the conceptual level.

31. I see a need to conduct [macroinvertebrate] monitoring, but when and where do the funds come from?

32. Although macroinvertebrate sampling is recognized as important, more critical issues at this time for our forest are anadromous fishes, other native fisheries, temperature, flow, and sediment monitoring.

NFS, Region 8

33. My dream is that we can associate EPT numbers (i.e., the number of taxa in the insect orders Ephemeroptera, Plecoptera, and Trichoptera) to differing levels of stream health and use this as a quick and easy index of upstream conditions.

34. What is needed, and [what] we plan to develop is a systematic approach to using macroinvertebrate sampling as part of a planned monitoring scheme.

35. As a hydrologist, I find I have so many things dumped on my desk that there is little time to devote to a monitoring plan that is well organized and integrates biology, chemical, and physical parameters. Our monitoring program is underfunded and understaffed. I am referring to effectiveness monitoring...We have a great need for some updated baseline monitoring.

36. We are using analysis of box plots within a subecoregion to "red flag" problems. [We] will have GIS coverage [soon].

NFS, Region 9

37. We believe that to do more of this monitoring, [we] need to get people trained.

38. [Our Forest] is beginning to do some inventory work to establish baseline species lists. Many high-quality streams are on the Forest. We should be monitoring these for effects of land-use practices and recreational uses.

39. Invertebrates can be very useful, particularly at the project level. As we develop the "ecological units" we are find-

ing that the invertebrates are too numerous and variable (at species level) to indicate broad communities...whereas fish and mollusks are more manageable.

40. [There is much] need for aquatic macroinvertebrate sampling and monitoring. A big need is to tie macroinvertebrates...to ecological units.

NFS, Region 10

41. A video touting the virtues of macroinvertebrate monitoring would be helpful, particularly the success stories of the monitoring and its application to decision [making]... Here in Alaska...most of our streams are depauperate of macroinvertebrates so there has been little or no work done on them.

42. This method of monitoring is perceived as "too scientific" by Forest Service managers. Its value and sensitivity need to be highlighted and incorporated into our monitoring tool kit.

43. I have some concerns about the reliability [of monitoring data] we'll get with our flashy systems, but optimistic about the opportunities.

BLM, Alaska

44. The primary reason sampling has not been conducted [on our District] is the expense associated with accessing much of our district. We are considering...the BCI methodology. There is some concern about the applicability of this [method] to streams in Alaska. This [method] may not be for use in interior Alaska because the species tolerance lists are geographically specific.

45. One of the primary limitations to the use of macroinvertebrate data in Alaska is the paucity of information on the ecology of arctic and subarctic macroinvertebrate communities. Specifically, tolerance levels, facultative roles, community relationships, and limiting factors. Research is needed in these and other areas to increase the value and utility of macroinvertebrate data.

BLM, Arizona

46. Training is desperately needed in: 1. application of data; 2. interpretation of data; 3. collection methods/field techniques; 4. basic identification of collected macroinvertebrates. I believe [macroinvertebrate monitoring] is promising...It is fast, easy, scientific, and gives good information to apply to management decisions.

BLM, California

47. I lean toward this system of monitoring...The problem for myself and the staff I'm working with is lack of training to properly conduct accepted methodologies and identification of sample specimens...I feel that knowledge of aquatic macroinvertebrates is fundamental to our ability to argue effectively for proper aquatic-land management.

BLM, Colorado

48. It appears to me that [the BLM] is destandardizing the macroinvertebrate program, including direction, equipment, techniques, results, and level of interpretation. I think the BLM/NFS/others need to get together and standardize our macroinvertebrate programs so we can intervalidate and accept the results obtained within and outside our agency ... There should be standard methods for the issue(s) we're interested in, fisheries, riparian, sediment, temperature, mining, logging, grazing, etc.

49. [BLM aquatic ecologists] should standardize techniques, analysis, interpretation, and reporting... [BLM resource managers] should set objectives and select sites. [Ecologists and managers] should understand results...base management on results.

BLM, Idaho

50. None of our biological staff has had exposure to macroinvertebrate sampling. We intended to use the technique but aren't sure where to start.

51. If we could develop some sort of generic reference data set based on stream size, gradient, elevation, etc., it would sure make macroinvertebrate analysis more cost effective [by] greatly reducing the number of samples needed for meaningful analysis. [It would be] a desired future condition for bugs.

52. Using the USFS lab... was not timely. It generally took 16-24 months to get results...I feel that macroinvertebrate monitoring is excellent for baseline monitoring efforts and monitoring long-term water quality trends. I recommend that an effort needs to be made to compile all macroinvertebrate information at a state/regional level.

BLM, Montana

53. Declining budgets, shift of personnel from field positions to IRM/Administrative positions, and emphasis of District Managers on career management instead of resource management have essentially destroyed the District's water-quality monitoring program. No funding exists for outside (certified) analysis, or even in-house equipment maintenance/repair. The only two reliable monitoring options left in this district are riparian and macroinvertebrate sampling. I am sure [our District] is not alone in its [predicament]. Bureauwide, the number of soil scientists and hydrologists has declined dramatically over the last 10 years. I hope macroinvertebrate sampling can be integrated into assessing water quality.

BLM, Oregon

54. Our first need is much better systematics so we can develop a profile of our macroinvertebrate community throughout the basin from lower river to headwaters. We need to be able to locate sensitive species and to relate basic habitat elements to instream communities. We also need more detailed analysis as to systematics and habitats to monitor changes.

BLM, Wyoming

55. Management in BLM isn't committed to macroinvertebrate monitoring. If we ever get away from commodity driven management, we may be able to start managing resources.