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DAM REMOVAL RESEARCH: Status and Prospects Graf, ed. THE HEINZ CENTER

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Status and Prospects

William L. Graf, editor

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Keynote Address: Myths and Challenges in Natural Resource Decision Making

William W. Stelle

Preston Gates and Ellis

The proper role of science is to light candles in dark corners.
—*Bruce Babbitt*

The history of dams in the United States provides a wonderful vantage point from which to view the cultural, economic, and social development of modern-day America. Dams have served over the last century as powerful engines of economic and social development across the American landscape. They are a part of our history and our culture. This rich history fuels the present-day debates over the rightful future role that dams should play in our tomorrow amid the changing social and cultural values of the 21st century.

Decision making in the United States about the management of the land and natural resources is extensively delegated across multiple federal, state, and local authorities. This dispersion of authorities and

Editor's note: The keynote address by William Stelle set the stage for the dam removal workshop. His comments and observations, based on his extensive government service dealing with the connection between science and policy, provide useful background for the other chapters in this volume.

responsibilities affects directly future decision making about whether and how to remove dams that arguably no longer serve compelling public purposes. It also promises to ensure that proper management of the governance of decision making will be as vital to good decision making as the quality of the empirical information that purportedly informs that decision making.

The Heinz Center Panel on Economic, Environmental, and Social Outcomes of Dam Removal has done good work in outlining a solid framework for analyzing the choices of maintaining or removing the many small dams whose substantial age, poor condition, or lack of current utility will rightfully generate a legitimate discussion of retention versus removal. It also properly assumes that numerous scientific disciplines may bring helpful tools to bear on those choices.

In my remarks today I seek not to add my two cents to the helpful discussions that will ensue over the next several days on the capacity of science to shed light on those choices. Rather, I choose to step back from those grainy details and offer you a clutter of random observations about the role of science in natural resource decision making based on my experience in the wonderful rough-and-tumble of natural resource policy and politics in Washington, D.C., and in the Pacific Northwest.

Decision making in the natural resource arena—as in many other arenas—is complex, hard to fathom, and characterized by the interplay of numerous factors, some of which are apparent, others of which are invisible. Scientific information is, obviously, one major set of factors at play, but it is only one of many. Understanding the role of science and its limits is important to increasing its relevance. My remarks are designed to touch on those limits in the hopes that you, as scientists, can therefore fashion your scientific inquiries and the information they generate in a more effective and influential manner.

Many myths surround the role of science in decision making. Some of those myths are part of the culture of the scientific community, while others find their place in our broader culture and affect how science is received and used. Identifying those myths and dispelling them when necessary will affect the use of science in decision making. I will therefore sketch some of the more powerful myths at play in the recent dam removal debates in the Pacific Northwest. I will identify several of the genuinely tough issues that decision makers may face in deliberating on whether to retain or remove dams in the hope of stimulating the thinking of workshop participants on how science might shed light on those tough issues. I will close my remarks by identifying some of the important scientific opportunities that lie ahead in fashioning a more sophisticated means of constructing a scientific approach in this arena.

THE MYTHS

Myth One: Science Is Truth. People confuse science with truth, and many scientists suffer from this same confusion. Science is not truth. Science is a highly disciplined and refined method for observing events through empirical measurement and attempting to discern relationships (correlations) based on those observations that will help to explain why things happen and predict what may happen in the future.

You may choose to believe that science is truth—and many scientists make this choice out of dedication to the scientific method or to tunnel vision or to hubris. Others may believe that the Scriptures are truth. Or that the coyote and the bear are truth. Others still may have no organized sense of truth, but merely a jumble of opinions and thoughts. My point here is not to argue whose truth is correct, but merely to encourage you, as scientists, to appreciate that you may equate your science with truth, but others do not and will not. This may help you to explain your science and to deliver it more effectively and persuasively into the cauldron of public debate over making choices.

Myth Two: Science Will Tell Us What We Should Do. This is a major myth that you should guard against. Science does not tell decision makers what they should do; they decide what they want to do and the scientific information may help to inform their choices on how to do it. This is a fine line, to be sure, and one that is crossed frequently. It seriously misstates, in my judgment, the proper function of science in decision making. It also may frequently serve as convenient political camouflage for those messy value choices or priorities that are better left opaque. Politicians and policymakers will often seek to justify their positions and choices on the grounds of "good science," whereas in fact their choices reflect a set of values and priorities that may have little to do with "good science." That their choices appear to flow from "good science" may frequently be more happy coincidence than causation.

The decision tree on dam removal espoused by the panel rightly identified the articulation of goals and objectives as a crucial first step in analyzing retention or removal choices properly. I fully support this, and believe it provides a good opportunity to delineate clearly the policy choices from the scientific information that may inform those choices.

Myth Three: Society Wants a Science-Based Approach. When you hear this, pay attention. It may be a genuine statement of preference, or, alternatively, it may serve as cover for a policy preference better left unstated. It may reflect for some a genuine dedication to the scientific method, and for others a political convenience. While this credo may be misused from time to time, the fact that it is useful is itself a cause for optimism for those who, like me, choose to believe in the relevance of the scientific method. Social attitudes are indeed shifting in favor of a more prominent role for scientific information. Reliance on science-based decisions is a basic tenet of many of the major federal and state legal regimes governing natural resources in public choices. Thus, in truth this myth is both myth and fact.

Myth Four: Something Will Happen Because the Model Says So. The misuse of modeling in natural resource decision making is routine. Understanding the proper role and function of modeling in scientifically based policymaking is genuinely difficult, and it is a difficulty shared by both scientists and decision makers alike. Models are important tools in predicting the future in a scientific landscape characterized by the wholesale lack of adequate data and information. Models also may serve as highly useful tools in organizing and manipulating large sets of data to better predict outcomes and enable people to make better choices. Decision makers hunger for greater predictive power as they struggle with difficult and important choices, and the scientific community properly responds with an ever more powerful model.

The major challenge for the scientific community is to protect against the misuse of models by its members or by decision makers. Transparency and effective communication about the assumptions and uncertainties that may be embedded in the models are both difficult and important. Often, the language of modeling is extremely obscure to the lay public, and thus caveats that seem clear to the scientific community

are completely lost in the din of public debate. Modeling becomes a tool of misinformation as much as a tool of useful information.

Myth Five: The Government Makes Rational Decisions. This may not be a widely shared myth across the kingdom, but it deserves mention if only for the faithful civil servants who toil under it. Government responsibilities for managing natural resources are broadly littered across the jurisdictional landscape at the federal, state, tribal, and local levels. Legislative bodies carve up these responsibilities by enacting overlapping laws in fits and starts of shifting political priorities. Agencies in executive branches then build power, constituencies, and influence through the aggressive implementation of their regimes. These regimes may or may not fit together nicely within one level of government—or fit vertically between federal, state, and local authorities. Their fit may reflect a larger rationale to which the legislature in its wisdom adhered. Or it may simply reflect the rough-and-tumble of the political process over time. Expect to encounter these overlaps and inconsistencies in agency missions and mandates. Expect further that they will, in turn, generate incentives for dueling science. Strive as best you can to insulate the integrity of the scientific exercise from the push and pull of interagency and intergovernmental dynamics.

Myth Six: We Want Somebody in Charge. Emerging from the clutter of intergovernmental jurisdictions is the oft-stated desire for order and accountability, reflected in the musings that somebody should be in charge. This apparent call for order arises with frequency in the raucous debates about dam removal in the Pacific Northwest, where a tangle of federal, state, tribal, and regional authorities characterize the bureaucratic landscape of natural resource management. There is less here than meets the eye. In fact, we want someone in charge when we are confident that they will do what we want. Where that confidence is lacking, we will frequently choose to protect and expand our independence, our autonomy, and our power. Science and scientists become the tools by which to obtain and exercise power and control. We want somebody in charge only insofar as that somebody will do our bidding.

THE CHALLENGES

Looking forward with enthusiasm, I caution you to not be too distracted by my tongue-in-cheek comments about the role of science in decision making. Social expectations in our political culture about the proper role of science in decision making are high and growing higher, which should be gratifying to those of us gathered here today who believe in the power and relevancy of the scientific method and to the broader scientific community. These rising expectations present us with important (and difficult) opportunities to improve the use of science in natural resource decision making. While the list of these challenges is no doubt long and expanding, I commend to you some of my favorites, including

- Helping to construct decision criteria that are clear, quantifiable, and reproducible
- Constructing improved scientific predictions in the face of limited data
- Using the scientific method to build trust and discipline among the relevant parties
- Developing methods to compare differing values fairly (profit compared with ecological function, biological benefits compared with power reliability)
- Fostering transparency in our science even while it increases in complexity
- Identifying and quantifying costs and benefits more accurately
- Overcoming scientific balkanization
- Improving communications about the limits of scientific information in the vigorous political and social debates that will no doubt continue

In an increasingly complex world, we can expect the power of science and the responsibilities of scientists to grow substantially. Good science has a hugely important role in improving decisions about managing our natural resources. Be mindful of the many myths and challenges associated with the use of science in decision making, and shape your recommendations over the next several days with wisdom. Thank you for the opportunity to join you today.

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American Dam Removal Census: Available Data and Data Needs

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Abstract: Although dam removal has recently received substantial attention from the press, the public, and professionals, little national-level information is available on trends in dam removal. This chapter presents the preliminary results of a national quantitative assessment of 20th-century dam removal trends. The study reveals the problems with the current data and the need to improve data collection, management, and dissemination strategies for information on dam removal.

Because it provided the best available dataset at the time, the American Rivers, Inc., dam removal list served as the starting point for developing a new database (American Rivers, Inc., et al., 1999). The primary limitation of the American Rivers list was that it did not distinguish between dams that were breached and those that were completely dismantled, a distinction that has important environmental implications and reflects different river management strategies. From the fall of 2000 through spring of 2002, entries in the American Rivers database were confirmed, corrected if necessary, and augmented with other cases obtained by calling state and federal agencies associated with dam management. Although the American Rivers list includes even the smallest structures removed from rivers, the database presented here includes only dams that were, before dismantling, at least 1.8 meters (6 feet) high or 30.5 meters (100 feet) long. This threshold was adapted from the criteria for inclusion in the National Inventory of Dams (NID) and was established to emphasize dams of substantial environmental significance.

Database analysis indicates that the number of dams being removed and the size of structures being removed have increased in recent decades. Dam razing, which is centered in the northeastern and West Coast states, is motivated primarily by safety concerns or interest in restoring river ecosystems. Even though over 400 dams have been removed from U.S. rivers, the ecological consequences of dismantling dams remain largely unknown.

These data provide preliminary insight into dam removal trends, but the utility of existing dam removal data to scientists, managers, and the public is currently limited by several factors, including (1) differences in reporting styles and nomenclature, (2) inadequate collection and integration of various reports and studies relevant to removal of a given dam, and (3) lack of centralized data management.

RELATIVE TO their extent, American rivers are collectively the most regulated hydrologic system in the world (Heinz Center, 2002). According to the U.S. Army Corps of Engineers (1999) over 80,000 dams fragment this nation's streams. If the definition of *dam* is extended to the smallest structures, the number may actually exceed 2 million (Graf, 1993). These dams provide valuable services such as hydroelectric power, water supply, flood control, navigation, and recreational opportunities. However, in the past decade the idea of removing dams has received substantial social and political attention because of changing social values and the age and safety of existing structures. In some instances (e.g., Two-Mile Dam in New Mexico or Waterworks Dam in Wisconsin), it has turned out to be less expensive to remove the dam than to repair or replace the structure, opening the door for consideration of dam removal as a management alternative. In addition, scientific research, particularly during the past few decades, has increasingly demonstrated the environmental costs associated with dams and their operations. Dams have caused large-scale environmental degradation of most major rivers in the Northern Hemisphere (Dynesius and Nilsson, 1994). They modify the natural hydrology, nutrients, and sediment dynamics of streams, and thus the biological and physical characteristics of river ecosystems (Petts, 1984; Williams and Wolman, 1984; Ligon et al., 1995; Pizzuto, 2002; Shafroth et al., 2002; Stanley and Doyle, 2002). These altered conditions may benefit introduced species but they can have deleterious effects on native species reliant on more natural conditions.

Large dams (e.g., Glen Canyon Dam and Hoover Dam on the Colorado River) store a disproportionately large amount of water and sediment relative to smaller dams (Graf, 1999) and thus often change riverine ecosystems substantially (Doyle et al., 2003). For example, after the closure of Glen Canyon Dam, major adjustments in sediment load, downstream hydrology, and water temperature modified channel geomorphology and aquatic and riparian habitats (see overview in Collier et al., 1996). An artificial flood was released in 1996 in an effort to improve downstream conditions, but a recent study suggests that the benefits of this strategy were limited (Rubin et al., 2002). Although more science is needed to aid dam managers and operators, the approach of mitigating the deleterious environmental impacts of large dams through modification of their structure or operations is receiving more attention. By contrast, smaller structures that may have limited economic and social benefits or need expensive safety and environmental upgrades appear to

be candidates for removal. Some dams meeting these criteria have been removed in the past several years, such as Edwards Dam in Maine and Colburn Mill Pond Dam in Idaho.

As the topic of dam removal gains national attention, basic information on razed dams is needed at the national level. Scientists investigating past removals to generate theories on the responses of river systems to this action should identify research sites where dams were once in place. Dam and river managers and agencies faced with considering dam removal are often interested in information that can be gleaned from other dams that were removed, particularly those with similar environmental surroundings or restoration goals. Public interest in this issue is rising as well. Not only does dam removal peak the interest of people through national headlines and controversies, but communities increasingly participate in the process of considering dam management alternatives such as dam removal.

Without the availability of high-quality, national data on dam removal, studies to date have been limited to discussing dam removal trends for particular states with good databases (Born et al., 1998), or to estimating national trends using information provided by American Rivers, a nonprofit river advocacy organization (Doyle et al., 2000; Poff and Hart, 2002). American Rivers may have the most accessible and comprehensive national information (widely available on their Web site at http://www.americanrivers.org), but some potential users have concerns about the advocacy nature of the organization. In addition, its list of razed dams does not always distinguish between dams that were removed and those that were only breached. These actions may have significantly different economic costs and environmental consequences.

The objective of the ongoing study described in the rest of this chapter was to compile and analyze a national database of dams that were removed completely and intentionally. The study seeks answers to fundamental questions, including:

- How many dams have been completely dismantled in the United States and for what purposes?
- Have the average and maximum size of razed dams changed in recent decades?
- Which states are removing the most dams?

The following sections describe the data collection process and the preliminary results and then discuss the problems associated with the current information available on dam removal and recommendations for future data collection and management.

MATERIALS AND METHODS

Construction of a dam removal database was the first step in the analysis of dam removal trends. The databases of agencies that keep dam incident reports (e.g., National Park Service, National Program on Dam Performance) were examined for removals, and dam removals were added from the American Rivers database after verification of removal by the responsible agencies. In addition, a series of formal letters sent to federal and state agencies and organizations involved in dam removal (e.g., Federal Energy Regulatory Commission, state water and environmental departments, state dam safety officers) requested information on dam removals and, when appropriate, asked persons to verify and augment data obtained from existing databases and correspondence with other agencies. All data from these letters were entered into a Microsoft Office Access database for further analysis.

Although numerous characteristics of the dam removal process are of interest to managers and scientists, this preliminary study focused on basic information about the structures, including dam height, length, location, year of removal, and reason for removal. The intent is to build other fields into the database as the research process continues. Two criteria are used for inclusion in the database: (1) intentionally, the dam was completely removed; and (2) the dam must have been at least 1.8 meters (6 feet) in height or 30.5 meters (100 feet) in length before dismantlement. The rationale for use of these criteria is twofold. First, the intent was to examine change in the decision-making process (*intentional* removal), rather than removals with incidental origins such as those associated with floods and failure. The constraint of *completely* removed eliminates structures that have been only breached. Including breached structures was impracticable in terms of data quantity. Furthermore, the economic costs and possibly environmental consequences associated with breached dams differ from those associated with relative structures that are completely dismantled. Finally, insofar as possible, the height and width constraints were intended to be consistent with the National Inventory of Dams (NID). The structure and content of NID is discussed in detail elsewhere (U.S. Army Corps of Engineers, 1999), and NID data have been analyzed

by Graf (1999). Although the inclusion criteria for NID emphasize structure height and storage capacity, storage capacity information is lacking for many of the relatively small dams in NID. The storage capacity criterion was therefore replaced with a structure length criterion.

DATA ANALYSIS

Preliminary data analysis suggests that over 400 sizable dams were intentionally and completely removed from U.S. rivers in the 20th century. Dam removal appears to have been relatively uncommon before the 1970s, but this activity has escalated in recent years (Figure 2.1).

Poor recordkeeping may account in part for the infrequent dam removals cited in the early to mid-1900s. However, the data also may simply reflect that dams were newer and thus were less likely to have safety problems and aging structures and more likely to be meeting economic and social needs. The recent acceleration of removals reflects problems associated with aging structures, growing social interest in restoring rivers and fish passage, new funding opportunities to support dam removal, and national policies aimed at improving the safety of aging structures (e.g., Dam Safety Act of 1972, Water Resources Development Act of 1982) and mitigating the environmental impacts of these structures (e.g., Clean Water Act of 1977, Endangered Species Act of 1973). Although dam removal may be motivated by several factors, safety and environmental concerns appear to be behind most recent dam removals. A discussion of the primary reasons for razing American dams is presented in Pohl (2002).

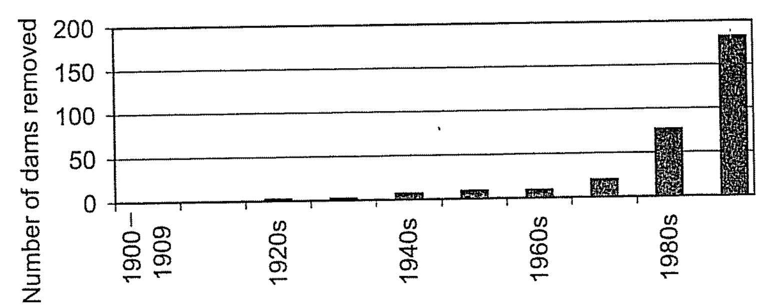

Figure 2.1 Dam removals in the United States in the 20th century.

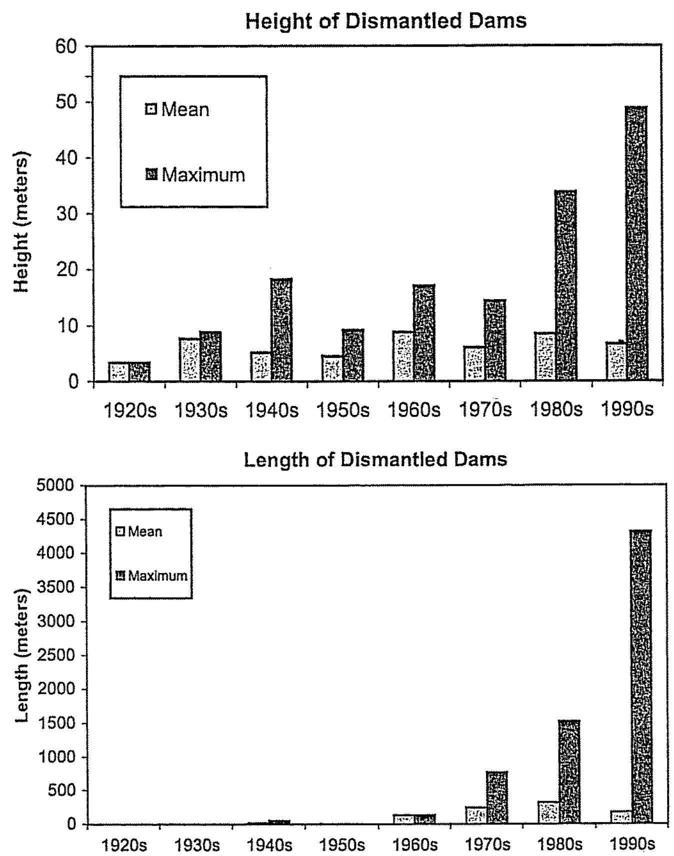

Figure 2.2 Height and length of dismantled dams by decade, 1920s to 1990s.

The mean height and length of razed dams have not changed significantly in recent decades because the few larger structures being razed are greatly outnumbered by many small dams that are relatively straightforward and inexpensive to dismantle (Figure 2.2). However, the maximum height and length of razed dams have risen in recent years, indicating a willingness to remove dams of significant size in certain cases (Figure 2.2). This trend is likely to continue as relatively large dams

(compared with most of those being removed) such as the Elwha River dams of Washington are removed in the near future.

Preliminary data analysis suggests that geography plays a role in the dam removal process. At present, dam removals are more common in the northeastern United States and on the West Coast (a detailed analysis of spatial trends is forthcoming). However, exploratory analysis suggests that the leading states are not those with the greatest numbers of dams or the oldest structures. Instead, states that have funding programs to support removal, agencies that take a leadership role in removal, and advocacy and community support are more likely to remove dams of low utility (Pohl, 2002.)

PROBLEMS WITH CURRENT DAM REMOVAL DATA

A major challenge in obtaining information on dam removals is that no one organization or agency has formal responsibility for collecting and compiling these data at the national level. State dam safety officers provide "incident" reports for dams in their jurisdiction, and this list may include removals. However, these incident report sheets are long and typically contain little information on dam removals because their main charge is the safety of existing dams rather than detailed reporting of a structure that is removed. The National Program on Dam Performance at Stanford University is making strides by establishing a central Web site (http://npdp.stanford.edu) for searching these incident reports, but to date few structures are found when searching under the term *removed.* A few federal agencies such as the National Park Service also keep incident reports for structures in their jurisdiction, but these valuable resources are limited in geographic extent and focus on specific removals. Thus much of the information on dam removals is found piecemeal through various local, state, and federal agencies and organizations that have responsibility for (or interest in) dams, water, and environmental quality. Collecting data from a wide variety of sources is a long and taxing process, serving as a major barrier to the analysis and dissemination of data on national dam removal.

A second significant problem with dam removal data stems from the varied sources of information. Information on dam removals from any given source tends to be incomplete—that is, limited to the data of interest to a particular organization or agency. In addition, the information is presented from using various reporting styles (e.g., different units of measurement) and nomenclature. These inconsistencies can be corrected with sufficient metadata, but the units are not always clearly indicated in reporting forms. Also, the terms used can be ambiguous. For example, "height" is often available for razed dams, but is this structural height, dam height, or hydraulic height? Because the dams are no longer in place, field verification of reported information is not possible. Finally, even the term *removal* offers challenges. Some dams originally reported as removed were not dismantled, but rather breached or lowered. Agencies interpreted removal broadly even though they were given specific criteria in request letters. These differences in reporting styles and interpretation influence the quality of the data collected on dam removal.

For recent and impending dam removals, sources can often provide a list of engineering or environmental studies that were or are being conducted in association with the removals. These studies provide valuable information on the dam structure and operations, the local environment, why the structure was dismantled, and removal strategies and impacts. However, for dams removed more than 10 years ago, the likelihood of finding detailed sources of information on the removal process declines sharply. In past decades, dam removal was not a major issue, and the investigations, if conducted, are not readily available. Often, sources indicated that they were unaware of any studies conducted before, during, or after the removal, but suspected that there was information "somewhere in the office." Office staff who were able to provide a report often indicated that other studies were probably conducted, but the location of the complementary studies was unknown. Thus the detailed information needed for analyses of dam removal trends and impacts is difficult to access.

RECOMMENDATIONS AND CONCLUSIONS

The preliminary results of the study described in this chapter indicate that the number and size of American dams being removed are increasing, and that dam removal efforts are centered in particular states and regions. However, the validity and utility of these trends are dependent on the data used for analysis. Currently, information on dam removal is difficult to obtain and often limited in quality and comprehensiveness.

As suggested elsewhere (Heinz Center, 2002), perhaps the most valuable step that could be taken to remedy this situation is establishment of a national database on dam removals, similar to the National Inventory of Dams, to be managed by a central agency. Such a database would greatly facilitate access to the data and would help to solve the problems with different reporting styles and nomenclature. If this is not possible, a lead organization such as the Stanford University's National Performance of Dams Program could greatly improve the consistency and quality of data by developing a reporting framework that could be used by the diverse agencies and organizations when collecting and reporting dam removal information. This effort would be of limited benefit, however, without a commitment by the agencies and organizations involved in dam removal to provide the funding and personnel needed to track, collect, and report dam removal information. Many individuals contacted in this preliminary research indicated that they were interested in collecting these data, but that their offices had other priorities that limited their ability to concentrate on dam removal.

Dam removal is now receiving substantial national attention because of interest in its economic, social, and environmental consequences. Basic research on dam removal is key to developing greater scientific understanding and a foundation for management decisions, but the limited data on razed dams constrain researchers' abilities to evaluate dam removal trends and to investigate the consequences of past dam removals. If the quality and consistency of dam removal reporting improve, scientists, managers, and the public will have a better foundation from which to advance their understanding of this national issue.

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