

Watershed Management in the 21st Century: National Perspectives

Carolyn Adams¹, Tom Noonan², and Bruce Newton³

Abstract.—Watersheds will continue to be planning management units of choice during the 21st century. Historic precedent, contemporary beliefs, regulation, and broad institutional support have insured their future. Whether their use will result in more sustainable systems depends on keeping natural resource issues a high national priority, balancing competition for consumptive resource use, advancing technology, developing strong public policies, and continuing appropriate research and supportive governmental policies. Further, it appears that successful watershed management will advance because organizations promoting its use tend to be highly adaptive, constantly seek new sources of information, and strategically use processes that foster innovation.

Introduction

As Americans look ahead to the 21st century, we recognize that we are in a position rarely matched in our nation's history. Our country has incredible prosperity and unparalleled technology, while experiencing dramatic and rapid changes. We view with pride some changes, such as medical advances, but other changes, such as the continuing degradation of our Nation's natural resources, especially our water, must be viewed with alarm. How can this nation continue to prosper without depleting its resource base? We need to enter the next century with our attention turned to how best to prevent, manage, or cope with the problems of gaining wealth at the cost of continued damage to our ecological systems (Killeen, 1999). Natural resource decisions, either by individuals or society, need to be framed in a meaningful context. Many believe that a watershed context provides this powerful basis for assessing environmental conditions and tracking the effectiveness of resource interventions. A watershed focus also provides a mechanism to bridge barriers between management agencies, a logical

¹ Director, U.S. Department of Agriculture, Natural Resources Conservation Service, Seattle, WA

² Water Resources Planner, Watershed Science Institute, U.S. Department of Agriculture, Natural Resources Conservation Service, Morgantown, WV

³ Limnologist, National Water and Climate Center, U.S. Department of Agriculture, Natural Resources Conservation Service, Portland, OR

geographic unit for technical analysis, and perhaps most importantly, an understandable and tangible landscape unit for engaging the public.

In this paper we explore the following questions: will the use of watersheds as the framework for natural resource management increase as we move into the next century; and will that provide a reasonable structure for successful coping mechanisms to deal with the predictable and unforeseen challenges?

A Brief Retrospective: How We Got Here

The United States has a long history of water management. In the first half of the 19th century, water management was strictly a local concern. Private citizens petitioned their town for permission to build structures to power a mill or to develop a private water supply system. Abuse of rivers was constrained primarily by public nuisance provisions from English common law. Late in the same century, Eastern and Midwestern cities with political power and financial resources condemned expanses of land for the development of water supply reservoirs. They acted unilaterally because no other level of government or segment of society claimed authority over water resources. In the West, water rights became the provenance of state government, which enacted laws to define water rights and settle disputes. The scarcity of water in Western states led to water rights laws based on codes of behavior originating with prospecting miners. Foremost was the concept that first in time was first in right. Toward the end of the 19th century, a series of disastrous floods in the East prompted calls for flood control. The U.S. Army Corps of Engineers (the Corps) was directed to build projects that "harnessed rivers" to protect life and property from floods. The Federal government also expanded its authority over water resources with the Rivers and Harbors Act of 1899. This Act extended federal authority to all navigable waters and prohibited the construction of any structure or the modification of any waterway without the expressed recommendation of the Corps' Chief Engineer and the authorization of the Secretary of War.

The early 20th century saw considerable activity at the municipal level. City Public Works departments constructed drinking water systems, built supply reservoirs, and installed sanitary sewage treatment works. Private power companies constructed hydroelectric dams. In 1902, under the Reclamation Act, the Federal government began the business of water development for irrigation supply in the West, primarily carried out by the Department of Interior's Bureau of Reclamation (BOR). The 1927 Rivers and Harbors Act significantly expanded water resource programs of the Corps and authorized the agency to develop comprehensive multipurpose plans for every river basin in the United States. By mid-1930 the Corps had prepared more than 200 plans, which became the basis for much of that decade's dam construction boom. The Corps and the BOR guarded their jurisdiction and actively opposed the establishment of other federal or regional entities. Even so, the 1930s saw the entry of several new players. The U.S. Department of Agriculture (USDA) was directed to reduce flood damages through watershed studies and land-based measures. The Tennessee Valley Authority (TVA) was established in 1933 with authorization to build dams (USDA, 1972; NRC, 1992). Largely motivated to stimulate the economy, the Federal government began a large program of dam construction in the 1930s. This era of large public expenditures for water structures continued until the 1960s. After World War II, USDA became a major player when the Soil Conservation Service (now the Natural Resources Conservation Service or NRCS) began building projects in upper watershed areas.

Throughout this period, concern about cost efficiency and interagency battles led to the establishment of several commissions charged with coordinating the federal agencies involved in water resources; the Corps, the BOR, the Public Health Service, and SCS. Those commissions failed largely because the politics of deciding which projects would be built where became very important to Congress. They resisted any attempt to interfere with the "pork barrel politics" that could benefit a Congressional representative so significantly (Riley, 1993).

After decades of failed attempts to coordinate water policy, the Water Resources Planning Act was enacted in 1965 to establish a National Water Resources Council (WRC) and several regional river basin commissions. The Act provided for the Council to develop water policy and to provide financial assistance to the states to support state-level water planning. Interstate basin commissions could be established to coordinate water supply, sewage and flood-control districts, state water resource agencies, the Corps, BOR, SCS, and the Environmental Protection Agency (EPA). Interstate commissions were to prepare and update coordinated plans and conduct data collection and studies (Fairchild, 1993). In 1972, the Clean Water Act was passed and it too had a major planning component;

section 208 provided for a national program of "area wide" or regional water quality plans. Also in 1972, the Coastal Zone Management Act was enacted encouraging comprehensive planning for coastal areas.

By 1980 all of these programs, to some degree, had failed to fulfill their original promises. The main reason for widespread failure of the regional component of the 1965 and 1972 acts was that the major players refused to acknowledge the authority of the regional entities (commissions) that had been established. The Corps considered itself the nation's water planner and saw no benefit in cooperating with them. The Office of Management and Budget (OMB) saw its role of deciding which projects would go into the President's budget as threatened by the commissions (Fairchild, 1993). Congressional committees were opposed to what they interpreted as the WRC advancing the President's role in deciding project priorities. President Carter's "water project hit list" epitomized this belief when the WRC identified a multitude of water projects as inadequate in providing regional or national benefits (Riley, 1998).

Finally, the states saw these efforts as attempts to undercut their role in water planning and saw little reason to work with the commissions when they could get their projects funded directly from Congress. The states' perception was not unfounded since the Clean Water Act was, in fact, based on the belief that the states were unwilling or unable to control water pollution. The Act empowered the EPA to regulate cities and industries, run the permit programs, and manage the construction programs. The Act's 208 planning process and several other grant programs intentionally circumvented the states and provided funds to regional planning entities. As the states developed stronger programs through the 1970s and 1980s in order to win "delegation" of the Clean Water Act programs from the EPA, they increasingly opposed the efforts of regional planning commissions. The 208 plans had no buy-in from either state or local governments, and the EPA had no authority or funding to ensure that local governments followed plan recommendations. Thus, the plans developed reputations as bonanzas for consultants and unused documents. In 1981, the WRC was abolished by the Reagan administration and the Federal government largely abandoned basin planning. In the early 1990s, the EPA renewed the call for a "watershed approach" to environmental planning. The EPA was motivated by the need to engage local entities in nonpoint source control and ecological restoration efforts for which federal authority is inadequate (USEPA, 1991).

What lessons can be learned from the history of watershed planning? First, the public mind-set and state/local laws about water resources varied historically and continue to do so from east to west and from cities to small towns based on scarcity of water and community wealth. Second, the fragmented nature of the local-state-federal

governing structure in the U.S. and the decentralized authority of agencies at all levels of government create barriers and challenges to integrated, comprehensive watershed or basin management. Third, the top-down model in which federal agencies act as the primary decision-maker draws strong resistance from state and local entities. Finally, planning agencies at any level of government must have adequate authority through either financial resources or policy-making authority.

Contemporary Predicament: Where Are We Now?

Given the lack of clear success historically in the managing the nation's water resources, what is our contemporary situation? To understand the present, the authors examine the primary influences on resource management at the watershed scale in this decade: the drivers, enablers, and state/federal support for watershed use.

Drivers: External Forces

Public Health and Expected Levels of Livability

Many institutions are revisiting or establishing new commitments to their constituents regarding environmental legacy; i.e., creating a vision of what kind of landscape should be passed on to descendants. For example, the Commonwealth of Pennsylvania's Constitution states in Article 2, Section 27, "The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations to come." This constitutional right became the basis of the state's 1998 Report of the 21st Century Environment Commission that recommends a comprehensive framework to conserve natural resources for sustainable use and make a healthy environment for healthy people. The framework depends in large part on comprehensive watershed management as an implementing mechanism. Other institutions and governments have similar initiatives and activities.

Pervasive Focus on the Essential Need for Clean Water

Arguably, water is the most necessary and recognized public natural resource. Concern for clean (drinkable, swimmable, and usable) water is a major influence on the

increase in watershed activities. In the 1990s, there have been outbreaks of microbiological contaminants (including such bacteria as *Cryptosporidium*, protozoa, and viruses) in drinking water, increased issuance of "boil water" notices, beach closures, fish kills, and elevated levels of nitrate in drinking water that pose immediate threat to young children. These situations fuel public and government concern about watershed functions and how the processes relate to the quality of potable water.

Regulatory Shifts

Since the 1970s, control of point-source discharges within our watersheds has been hugely successful due to the installation and upgrading of treatment facilities by units of government and industry. With these severe problems largely under control, nonpoint source runoff and aquatic habitat degradation are now considered the most significant impacts on water resources. Millions of individuals own nearly 70 percent of the land base in our Nation and each is responsible for generating some nonpoint pollution and habitat degradation. As a result, recognition that regulation of nonpoint sources is not culturally acceptable, cost effective, or practical to implement is increasing.

In response to this recognition, governments at nearly all levels are committing to more locally based systems of regulation and citizen-based actions involving communities. Many believe that these multitiered, citizen based processes may be the most effective ways of institutionalizing the underlying values necessary for lasting resource management efforts (Lee, 1996).

Belief in an Environmental/Economic/Community Equilibrium

Leadership in the U.S. believes that Americans can "have it all." "All" broadly defined means sustainable development; i.e., environmental health, economic prosperity, and social equity and well-being (President's Council, 1996). Some ecologists refer to this belief as the "Nature Balanced" view or a belief system based on the notion of logical growth and the challenge of navigating through demographic, economic, social, and environmental shifts to reach a plateau of sustainability (Gunderson, et al., 1995). Much scholarship and many policy changes are being driven by this belief. This equilibrium concept is a clear, intellectually appealing force, but as yet, its attainability is unknown.

Strong Feelings about Environmental Values, Community, and Future Generations

The American public has valued the environment, community, and responsibility to future generations since the early 1960s (Kempton, 1995). Some of these values

now are evolving into the use of watersheds as spatial units for planning. In part, this comes from widespread public and political recognition that ecological identity or one's "watershed address," relates water resource concerns to one's nearby environment. Thus, environmental health for one's descendants is more likely to be perceived as a product of individual efforts in local communities rather than by centralized regional or national institutions. As U.S. Senator Kit Bond from Missouri stated in a recent press release, "I believe that a 'one size fits all' approach no longer works. I believe that states and localities, instead of Washington bureaucrats, are best able to make environmental decisions and set priorities." While this statement rings of political rhetoric, it was followed by the Senator's acquisition of \$3 million in funds for the Missouri Watershed Initiative.

Enablers: Supportive Forces

Increasing Quantities of Resource Data at Large Spatial Scales

Satellites, aircraft, and ground-based instruments constantly collect data. At least 30 earth observation satellites and sensors were on observational missions in June 1999 using optical and near-infrared radiation and radar (active microwave) to generate visible images. The World Wide Web's remote sensing virtual library lists hundreds of sites for satellite data and remote sensing conferences, societies, documents, journals, news groups, and resources. An explosion of natural resource data is available as is the proliferation of regional and watershed scale assessments and plans. Paradoxically, even though remote sensing data has exploded in quantity, we still lack basic information on the status of resources that cannot be assessed using remote sensing such as the ecological condition of aquatic resources or status and trends in water quality (Paulson, 1998).

Increased Cooperation Between Organizations

Historically, myths, paradigms, and ideologies that represent special viewpoints drove institutions and organizations. When fewer paradigms exist and organizations work toward shared viewpoints, the flow of information and resources increases, learning occurs, and people coalesce toward action (Westley, 1995). In the 1990s, collaboration between natural resource agencies is being provoked, to a large degree, by downsizing and associated fund reductions and personnel. Whether stimulated by scarcity or perceived benefits, experienced watershed practitioners know that finding common ground through cooperation and building partnerships is leading to wider acceptance and quicker implementation of actions that benefit natural resources.

State and Federal Watershed Leadership

State Supported Strategies

State governments are now taking active roles in encouraging and requiring watershed management approaches, particularly for the reduction and elimination of nonpoint discharges to water. Kentucky, South Dakota, and Texas promote the use of statewide approaches; California and Oregon have assembled watershed-based project inventories and river information systems, while Massachusetts and Wisconsin have reorganized state agency structures to coincide with watershed or basin boundaries. The general trend is for states to take an active leadership role in resource management and to use watersheds as the basic planning unit.

Federal Strategies

Federal agencies, led by the authority and persuasiveness of the White House and the Clean Water Action Plan, are strongly supporting and advocating the use of watersheds (CWAP, 1998). The greatest federal emphasis is from the EPA's Office of Water. This office provides massive quantities of resource information related to watershed management in the form of publications, web sites, videos, training, and educational material. The monitoring aspect of watershed work is strongest from the U.S. Geological Survey's Water Resources Division and their NAQWA program, and on land technical assistance is the primary focus of the USDA's Natural Resources Conservation Service. The 1996 "Farm Bill" statute redirected financial support for conservation toward priority areas to better align resources with watershed planning efforts. The trend is clearly toward federal leadership in using watersheds as a basic planning unit.

Prospects for the 21st Century: A Potpourri of Opinions

*The world is not run by thought, nor by imagination,
but by opinion (Drew, 1926).*

If indeed the world is run by opinion, what are our opinions with regard to how natural resources will be managed in the U.S. of the 21st century? Will a focus on watersheds influence scenarios for management? The authors used an informal query of opinions to gain some insights into these issues by asking knowledgeable professionals where they thought the nation might be and where it might go with regard to watershed management. Four questions were directed toward these professionals:

- How will people's attitudes toward natural resource issues change in the 21st century?
- What factors will cause those changes in attitudes?
- What do you think should be the primary role for the Federal government in watershed-based resource management in the 21st century?
- What motivations will encourage people to use a watershed approach in the 21st century?
- What will be the top three research needs for watershed management in the 21st century?

This was not a scientific study, thus no sampling techniques were applied. The authors received responses from 22 people from different areas of natural resource management. The individuals contacted work for a variety of governments and organizations including the Audubon Society, the Charles River Watershed Association, the Chesapeake Bay Commission, the South Florida Water Management District, Texas Natural Resources Conservation Commission, The Watershed Coalition, the University of Maryland, and the EPA among others. Many regions of the country are represented as well as job positions including policy makers, researchers, land managers, administrators, and natural resource managers. The synthesis of these conversations provides a compelling story about attitudes and societal direction for natural resource and watershed based activity for the 21st century.

Attitudes toward Natural Resource Issues in the 21st Century

In general, respondents described a strengthening in attitudes for natural resource awareness in the 21st century. Few consistent responses emerged about possible changes in citizen attitudes. Some believed that there will be a broadened focus on natural resources and an increasingly educated population will have a growing positive awareness of resource values. Some, but not all, thought these changes could relate to watersheds rather than political boundaries. A thread throughout the responses suggests that people will become possessive about natural resources and more demanding about their preservation and protection. This sense of urgency is countered by others who stated that environmental concerns will be lessened and more localized—a continuation of a current trend where people are now more interested in their backyards, less globally aware, and somewhat complacent. On the other hand, some thought that environmental

awareness is now growing again in the late 1990s, after a strong beginning in the 1970s and a waning in the 1980s and early 1990s. Several said that natural resource issues might rise to a top priority.

Various rationales were given as to why people will become more involved, more focused and increasingly linked on natural resource issues. Changed attitudes and behavior will be the product of personal experiences, environmental education, media activity about ecological problems, and a result of technological advances that permit instant connections among a concerned citizenry. Respondents overwhelmingly believe that these changes will be driven by three primary factors: degradation of the environment, accompanied with associated declines in the quality of life; potential shortages of natural resources as commodities; and technological innovations that will keep decisionmakers and the public better informed.

Degradation of the Environment

Respondents felt that the public's witness of ecological degradation will help sharpen their viewpoints, especially degradation that results in decline of quality of life and increased costs of pollution control. Citizen attitudes will be influenced by personally experienced environmental degradation and impacts resulting from increased development, flooding, increased fragility of resources, more urban sprawl, loss of habitat, and more pollution problems moving from the city to rural areas, such as air pollution and poor water quality. Additionally, an increasing population will direct more and more pressure on natural resources. Some conjectured that these conditions would push people to seek solutions, such as more emphasis on protection of green space and natural habitat. People will become more informed about environmental issues and less tolerant of pollution. Attitudes in the 21st century may be further influenced by an expected clarification of the connection between degraded environmental conditions and negative human health.

Competition for Resources

Several respondents commented that people would view natural resources as commodities, with an increased eye to their extraction. Some stated that natural resources will simply become more limited, thus more expensive, and this scarcity will play an important role in a sharpened focus on them. One respondent thought a growing recognition that the "world is no longer empty" will be a major driving force, and that technology will be redirected toward conserving natural capital. In fact natural capital may be increasingly recognized as the limiting factor instead of more traditional measures of economic capital.

A number of respondents mentioned the increasing view of natural resources, especially water, as a com-

modity, and suggested that future debates will argue their true economic value. Expected population increases will demand more of these already stressed resources, and water scarcity will become a more crucial and controversial issue, especially in the more arid areas. The true costs for having abundant and clear water will sharpen the issue in the public's mind. Arid areas will seek more water, and those "areas of plenty" will view it more protectively, thus intensifying public debate and making a key natural resource the subject of intense economic concern. With increasing scarcity people may be willing to pay more for their consumptive use, but at the same time, more to protect them. Unfortunately, this protection could come mainly from an impetus to control resources rather than from an educated understanding of ecosystems.

Technological Contributions to Informed Decisionmakers and Citizens

Several respondents believed that the rapid availability of information to decisionmakers and citizens via new technology (i.e., the Internet) could affect what they know and understand and thus, influence their attitudes about natural resources. Computers and web sites will continue to provide increasing amounts of information on watershed issues, the overall environment, and environmentally induced illnesses. The availability of digital data should enhance availability and management of information for scientific evaluation and information sharing.

One professional suggested that technology breakthroughs might increase general knowledge and understanding of ecological impacts from different stressors on humans and other biota. This would result in greater abilities to intervene in ways that will achieve watershed management goals with a higher level of predictability. This broad and hopeful thought, one full of promise and challenge, might prove to be the most prophetic.

Future Role of the Federal Government in Watershed Management

Respondents thought that state and regional entities are best equipped to handle local issues and problems, but believed that the Federal government has several significant roles. The roles suggested are not necessarily new, rather the respondents' opinions of roles for which the national government is best suited. The majority of resource professionals contacted believed appropriate federal roles should be: a) providing funds and incentives while giving authorization to the states and regional entities; b) providing guidance and oversight, especially set-

ting and regulating minimum standards; and c) facilitating complex, multiparty, integrated resource management plans. There were also minority opinions expressed that the Federal government should provide baseline information, inventory and disperse data, and be a "patron" for small watershed efforts.

Funds, Incentives, and Authorizations

Overwhelmingly, the respondents stated that the national government has a substantial role in funding the efforts of states and regional entities. One comment was "Many of the solutions are simply beyond the funding ability of many states in which the key natural resource issues are located." The general sense was that the government is going in the right direction with environmental mandates accompanied by funding. Support was also given for incentives and increased authorization to the states and regional entities to pursue local solutions to local problems. The respondents believed that these approaches should continue and be enhanced.

Provision of Guidance and Oversight

Contributors think that the Federal government should provide methods, protocols, and education, and in general, serve as a communication link for providing information across political boundaries. The government should also lead regional, state, and local governments to work cooperatively along watershed lines. Some respondents thought an essential role is providing oversight through establishing and enforcing broad-based standards, such as TMDL's (total maximum daily loads). Reasonable standards should be set by the national government, but a primary role should also be to bring constituents together to identify, analyze and solve natural resource problems. This is especially important for large basin issues with implications for regional and interstate water resource management.

Facilitation for Complex, Multiparty, Integrated Resource Management Plans

One respondent noted that a "forgotten" role of the national government is to provide focus on regional scale or interstate resource management issues. It was further emphasized that the government should be "emphasizing, encouraging, and insisting on integrated resource management." Integrated management was described as going beyond traditional concepts of watershed management as surface water control. The federal level should clearly understand and promote an ecological systems approach that integrates the interactions between all systems—physical, biological, and atmospheric.

Motivations to Use a Watershed Approach

Respondents thought that motivations to use a watershed approach will be strikingly similar to the factors cited as those most likely to change citizen attitudes about natural resource management in the next century. They believed appropriate motivations should be crafted around economic incentives, education, and regulation.

Economic Incentives

Clearly, the use of money as economic incentive was a recurring theme among the responses. Mini-grants and financial incentives for planning and watershed coordinators were discussed. Several respondents replied that economic logic is also an appropriate motivator. For example, watershed approaches have been demonstrated to be cost effective when the cost for not dealing with watershed issues is computed (i.e., pollution abatement, treatment facilities, remediation, and restoration costs).

Education

The most pervasive response to the issue of motivations was that education, in its broadest concept, was necessary. Citizens need to understand what watersheds are, how they can be used as a framework to balance differing resource concerns, and how their use would be beneficial to encourage collaboration and sharing of limited resources. Perhaps most importantly is the understanding that watershed system-based approaches could replace piecemeal, quick fix solutions that often generate worse conditions than originally present. Education could reduce lack of understanding about how total watershed systems react to intervention.

Regulation

A few respondents expressed strong belief that voluntary watershed management is limited in its ability to produce results. One person noted that “people are set in their ways; the Federal government must mandate—then the voluntary part will happen after that.” Another noted that, “Many aspects of natural resources and the environment are essentially nonrenewable and must be proactively managed by those who are looking out for the long-term well-being of humans and other creatures.”

Perhaps the most blunt, but true, response about motivations to encourage the use of watershed approaches was that, “Everything else that has been tried has failed; it is the only way to deal with cumulative effects. Watershed approaches will be successful when governments realize they are very effective tools to gather citizens toward action.”

Research Needs for Watershed Management

The contributors provided a rich river of ideas about what watershed managers need under the general umbrella of “research,” though most used a liberal interpretation of the term. There was little to no duplication of ideas, so clearly a great deal about the field and practice of watershed management is still to be learned. Respondents stated that more knowledge is needed in the inquiry areas of planning (tools, methods and protocols), basic research, and applied research.

Planning (Tools, Methods, and Protocols)

Several of the ideas involved planning tools to deal with the human elements of watershed work including how to change behavior and how to use communication techniques for effectively working with communities. Others focused on tools for more abstract processes such as developing ways to preserve natural resources along with quality of life and determining the effectiveness of controlled growth and land use planning.

Basic Research

Identified basic research needs included: (1) improved understanding of surface water and ground water interactions and their effect on stream ecology, and (2) improved understanding of the effects of low concentrations and mixtures of potentially toxic compounds interspersed with seasonal pulses of higher concentrations on aquatic organisms. Others focused on nutrient management from a watershed perspective: (1) transport, fate and effects of nutrients on stream ecology, (2) source and control of nonpoint bacteria and true relative risk, and (3) prediction of loadings of phosphorus and metals, and (4) better information on sources and controls of agricultural runoff.

Applied Research

Most responses dealt with application and the need for action-oriented guidance. One respondent stated emphatically, “We are a research happy nation—need to start applying the research we have.” The applied research needs included: (1) cost effective water treatment technologies prior to discharge into natural systems, (2) decision tools that allow integration of natural resources with other activities so that system linkages can be portrayed, and (3) system tools for understanding urban ecosystems.

Predictions: A Summary

Does anyone have a crystal ball that will truly allow us to gaze into the next century with accurate predictability? Practically speaking, it is a great accomplishment if one can anticipate trends of the next 5 to 10 years. If current trends continue, it seems reasonable that the following will occur:

1. For privately owned lands, states will continue to support watershed organizational efforts, provide some financial incentives, coordinate with federal agencies, and orchestrate instate watershed management activities. Federal agencies will serve primarily in a technical support and facilitation role, provide some financial incentives, and continue to be active leaders in interstate and international efforts. On public lands, federal agencies will lead the planning and management activities, but with increased partnership from private land managers in the watershed.
2. States will increasingly adopt strong state statutes to require watershed planning and analyses, especially as it relates to the management of water resources. The Federal government will establish incentives for states to adopt strong statutes to support and provide oversight and guidance to watershed planning efforts.
3. The concept and practice of adaptive management will be increasingly critical and more frequently used in watershed management. Adaptive management starts with the recognition that the knowledge to predict the results of a resource management decision is often lacking. Major resource management decisions are approached similar to an experiment with monitoring and a process to evaluate results and modify the resource management plan in response to new knowledge.
4. Ecological sciences important to watershed management will continue to evolve at the same time as public agencies struggle with adaptive actions/reactions. Agencies will most likely still remain bogged down in inflexible policies and regulations; generally several steps behind leading edge of ecological knowledge.
5. Watershed planning processes will increasingly be bottom-up, locally based efforts that rely on strong citizen leadership and activism. Public dialog, ownership, and education will be critical. Nongovernmental organizations will increasingly

build bridges to the public and be effective moderators between adversarial parties.

6. Interdisciplinary work will be absolutely essential in watershed management, and more 'nontraditional' and arcane disciplines will be needed to address increasingly complex issues.
7. Effective watershed management will require that scientists agree on definitions for "success" and "failure" and establish thresholds for tolerance. Monitoring and evaluation will become essential components of all watershed projects that involve ecosystem protection, modification, or restoration.
8. Scientists need to find more effective methods of explaining their work to reduce confusion and the fog factor for the public and decisionmakers using watershed approaches.
9. Ecological changes in watersheds and basins caused by cumulative, seemingly insignificant, human actions will continue to cause surprises and sometimes disasters.
10. Analysis tools, such as geographic information systems and remote sensing, will become more affordable, sophisticated, and commonly used in decisionmaking processes. At the same time these tools will become increasingly mobile and accessible to the public. The availability of data will increase exponentially as dependence on the information highway (Internet) grows. Watershed planning will be confounded by the vast amount of data available and practitioners will struggle with how to manage it effectively and in a timely manner.

The 21st century in the United States will be an ever changing ecological, economic, and social environment. If watershed management succeeds as a viable tool for managing natural resources, it will be because visionaries are attracted to the challenge and because organizations involved are highly adaptive, encourage shared collaboration, are constantly open to new sources of information, and strategically concentrate on processes that foster innovation and learning.

Acknowledgments

The authors wish to thank Warren Lee, Director, Resource Inventory Division, USDA Natural Resources Conservation Service, and Sally Schauman, Professor, University of Washington, for their comprehensive technical reviews of this paper.

Literature Cited

- 21st Century Environment Commission. 1998. Report of the 21st century environment commission. Harrisburg, PA. 64p.
- Fairchild, Warren D. 1993. A historical perspective on watershed management in the united states. In Proceedings Watershed 93: A National Conference on Watershed Management. USEPA Center for Environmental Publications, Cincinnati, Ohio.
- Gunderson, Lance H., et al. 1995. Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, 593 p.
- Kempton, Willett, et al. 1995. Environmental values in american culture. Massachusetts Institute of Technology, Cambridge, MA, 320 p.
- Killeen, Tim, et al. 1999. The ecological crises of the 21st century. University of Michigan, p.8. Available: <http://blitzen.sprl.umich.edu/GCL/notes2/crises.html> (1999, June 9)
- Lee, Kai N. 1993. Compass and gyroscope: integrating science and politics for the environment. Island Press, Washington, DC.
- Lee, Robert G. 1992. Ecologically effective social organization as a requirement for sustaining watershed ecosystems. In Naiman, Robert J., Ed. Watershed Management. Springer-Verlag, New York, pp. 73-90.
- National Research Council. 1992. Restoration of aquatic ecosystems. National Academy Press, Washington, DC.
- Paulson, S.G., et al. 1998. Critical elements in describing and understanding our nation's aquatic resources. J. Am. Water Res. Ass. 34: 995-1005.
- Riley, Ann L. 1998. Restoring streams in cities: A guide for planners, policy makers, and citizens. Island Press.
- United States Department of Agriculture, Economic Research Service. 1972. A history of federal water resources programs, 1800-1960. Miscellaneous Publication No. 1233, Washington, DC.
- United States Department of Agriculture, Natural Resources Conservation Service. 1996. A geography of hope—america's private land. Washington, DC, 80 p.
- United States Environmental Protection Agency. 1991. The watershed protection approach: an overview. EPA 503/9-92/002.
- United States Environmental Protection Agency and United States Department of Agriculture. 1998. Clean water action plan: restoring and protecting america's waters. 89 p.