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Chapter 2 Drought Planning in the United States: Status and Future Directions

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Chapter 2

Drought Planning in the United States: Status and Future Directions

Donald A. Wilhite and Michael J. Hayes

Introduction

Drought has been a common feature in large portions of the United States during the past decade. To the casual observer, the frequency of recent droughts may signal a change in climate, a possible forewarning of global warming. Viewed in the context of the nation's climatic history, the pattern of the past decade is not unusual.

Recent droughts in the United States have resulted in significant economic, environmental, and social impacts. Many people are well acquainted with the serious impacts of the droughts of the 1930s and 1950s. The Dust Bowl of the 1930s is known worldwide as a classic example of the disharmony that can exist between human activities and nature, a pattern that has been repeated again and again in other areas of the world in the past several decades. The images of the Dust Bowl in the United States are now fading because a large percentage of the populace is too young to remember the hardships and suffering that resulted from this nearly decadal episode of drought. Droughts of the past decade have reminded us of our continuing vulnerability to extended periods of water shortage and the urgent need to prepare for their recurrence. Although technology has reduced our vulnerability to drought to some degree, it has also exposed new sensitivities.

Climate and, more specifically, drought were significant factors in the settlement of the western United States. As the wave of settlement moved westward, settlers were repelled repeatedly by drought. Some endured conditions at the arid frontier, but many returned to more humid eastern locations or continued westward to California, Oregon, and other seemingly more hospitable environments. The settlement of the more arid west represents

an ongoing struggle with climatic elements and a never-ending attempt to adapt to the harsh realities of nature. This adaptation process has proceeded undaunted, assisted by the development of many new technologies and government programs over more than a century that have helped to make this region more resilient to the vicissitudes of climate. However, vulnerability to drought remains and may, in fact, be increasing because of increasing and shifting population, industrial growth, the ever-increasing demands of large urban areas, pollution of many water sources, and the value now placed on water to ensure the health of natural ecosystems.

The primary purpose of this chapter is to provide an overview of drought planning and mitigation activities that have occurred in recent years in the United States. This discussion will be preceded by a brief description of the climatology of drought during the period 1986–1995 and a discussion of the deficiencies that have characterized the traditional reactive or crisis management approach to drought management. The development and implementation of state drought plans in the United States represents an important first step toward a more proactive, anticipatory approach to drought management. The transition from crisis management to risk management can only be achieved through a radical philosophical change in how drought is viewed by policy makers at all levels of government.

The Climatology of Drought, 1986–1995

Drought is a normal, recurrent feature of the climate of virtually all portions of the United States. Because of the country's size and the wide range of climatic regimes present, it is rare for drought not to exist somewhere in the country each year. Figure 1 provides a historical perspective of the percent area of the country (48 contiguous states) in severe to extreme drought, according to the Palmer Drought Severity Index (PDSI) (Palmer, 1965) from 1895 to 1995.¹ Severe and extreme drought represent values of ≤ -3.0 on the PDSI scale. PDSI values commonly range from +4.0 (extreme wetness) to -4.0 (extreme drought), although values above and below these levels are often computed. For example, during August 1977, PDSI values reached -7.0 in parts of the upper midwest and -9.0 in eastern Oregon and Washington. The PDSI, computed for each climatic division, has been until recently the only index used nationally to monitor or assess climatic conditions.

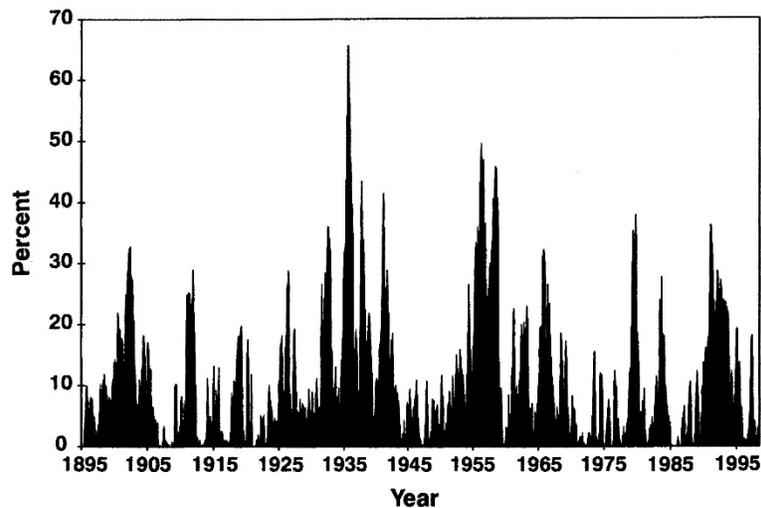


Figure 1. Percent area of the United States (48 contiguous states) in severe and extreme drought (i.e., ≤ -3.0), 1895–1995.

Figure 1 reveals two features of drought in the United States: the variable but recurrent nature of drought and the magnitude and duration of the droughts of the 1930s and 1950s in comparison to other episodes during the remainder of the century. Drought frequently affects more than 10% of the nation, and it is not uncommon for more than 30% of the nation to be affected. The most benign periods occurred around the mid-1940s, between the late 1960s and mid-1970s, and from 1978 to 1985. In contrast, the 1930s drought continued for nearly a decade; PDSI values of ≤ -3.0 (severe and extreme drought) affected approximately 65% of the country and more than 95% of the Great Plains at the peak of the drought in 1934. The 1950s drought began in the southwest and southern Great Plains states in the late 1940s and persisted through 1957. At its peak, severe to extreme drought affected nearly 50% of the nation.

Significant periods of drought affected large portions of the northeast in the mid-1960s and extensive portions of the West Coast, Great Plains, and midwestern states in 1976–77. In fact, 1976–77 remains the most severe short-term drought for parts of the far western states of California, Oregon, and Washington and sections of the Midwest. For this reason, this drought is often used by planners and water managers in assessing the vulnerability of water supply systems.

The most recent series of drought years began in 1986 (fig. 2). Dry conditions in late 1985 persisted through the midsummer months. Drought conditions extended from the south central states to the Atlantic Coast. The epicenter of the drought extended from central Tennessee and Kentucky to central South Carolina and from Virginia to central Georgia. Precipitation in the core area was $< 40\%$ of normal during the period from December 1985 to July 1986. In early August 1986, moderate (PDSI ≤ -2.0) to extreme drought extended from southern Pennsylvania to central Florida and west to central Louisiana. Moderate to extreme conditions also existed in California and the Pacific Northwest and in parts of the northern Rocky Mountain states and central Great Plains states.

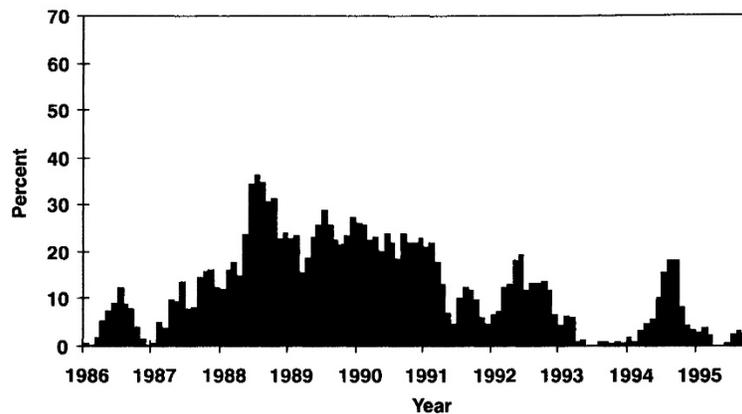


Figure 2. Percent area of the United States (48 contiguous states) in severe and extreme drought (i.e., ≤ -3.0), January 1986–October 1995.

Drought conditions abated in early 1987 but reappeared swiftly in the spring. Moderate to extreme drought was widespread over the western United States by August, and moderate drought reappeared in the southeast and spread west into the midwestern Corn Belt states. Pockets of severe to extreme drought developed in portions of the Tennessee, Ohio, and Mississippi River valleys, a forewarning of events to occur. By the end of 1987, approximately 17% of the nation was experiencing severe to extreme drought.

By April 1988, drought conditions in the west had deteriorated significantly. Severe to extreme drought affected all of California, Oregon, Washington, and Idaho; northern portions of Utah; and western portions of Wyoming and Montana. In addition, moderate drought had spread into eastern Wyoming and Montana. Significant pockets of moderate to severe drought had formed in Minnesota and eastern portions of North and South Dakota and in New England. Moderate to extreme drought persisted in the southeast. By late May, drought in the west, northern Great Plains, and upper midwest had intensified and spread into adjacent states. The drought area in the southeast also began to spread northward into Indiana, Ohio, Illinois, and Iowa. By late July, the intensity had worsened and the spatial coverage had increased. The drought areas in the west and midwest were joined, and moderate drought had spread throughout the south and into eastern Texas. Severe drought continued in New England, and parts of the mid-Atlantic coast were also affected. By August 1988 more than 35% of the nation was experiencing severe to extreme drought.

Dry conditions moderated during the fall and winter months as precipitation returned to normal for some areas and water demand subsided. By May 1989, the drought area was reduced to under 20% but quickly increased to nearly 30% by late summer. The most severely affected areas were California, Nevada, Arizona, Utah, Wyoming, and parts of Colorado and New Mexico. Portions of the Pacific Northwest were also affected. The drought in the midwest and northern plains states shifted south and west to affect Kansas, eastern Nebraska, Iowa, and northern Missouri. For the most part, drought conditions in the

southeast, mid-Atlantic, and New England states disappeared. The area in severe to extreme drought leveled off at about 25% in 1990 and continued at that level through 1991. The principal areas affected were the western states and portions of the northern Great Plains. A significant decline in the drought area occurred in early 1991 (to under 10% of the nation), peaking at 15% in July and rising slightly to about 17% in July 1992. Again, the drought area was confined mainly to the western states, including portions of the western Great Plains.

Drought conditions abated by mid-1993 for virtually all portions of the nation. Portions of the western states experienced what they believed to be an end to the drought that had been ongoing since 1986. However, much below normal winter precipitation over most of the region resulted in the return of severe to extreme drought conditions in 1994. By May, extreme drought extended from California and the Pacific Northwest to western Nebraska and northern Colorado. During 1995, drought conditions were widely scattered and principally in the moderate category for most of the nation. The primary areas of concern were the northeast, portions of the southeast, and portions of west Texas and eastern New Mexico. The wet winter of 1995–96 in the northeast effectively ended concerns about an inadequate water supply in this region during the 1996 summer.

The drought that affected western Texas and New Mexico in 1995 expanded into southern California, Arizona, and New Mexico and parts of Nevada, Utah, Colorado, Texas, Oklahoma, Kansas, and Nebraska in 1996. In April, most of the drought area of the Southwest and Great Plains regions was classified in the moderate category (PDSI values between -2.0 and -2.99), with only small areas classified in severe or extreme drought. By May, the PDSI showed an intensification of drought in this region, including most of the climatic divisions from southern California on the west to Arkansas and Louisiana on the east and portions of Colorado, Kansas, and Nebraska on the north. By mid-May, large areas were classified in the extreme drought category (≤ -4.0); these areas continued to expand in spatial extent through the early part of July.

Recent Droughts and Vulnerability

What lessons can be learned from this series of drought years in the United States? First, it reinforces the notion that drought is a normal, recurrent feature of the climate of the United States. Second, it suggests that no portion of the United States is immune to extended periods of precipitation deficiency. Some areas of the United States were affected by drought during seven consecutive years, and nearly all portions of the nation experienced drought of sufficient intensity and duration to result in serious impacts on more than one occasion during the past decade. Third, the character of drought differs considerably from one climatic region to another, resulting in profound impacts in many economic, social, and environmental sectors. Fourth, the series of drought years between 1986 and 1995 (fig. 2) is not unusual when examined in its historical context (fig. 1). Fifth, no apparent trend exists in the percent area of the United States affected by severe to extreme drought during the past century, although a local or regional scale analysis might produce different results.

What about future occurrences of drought in the United States? Is the frequency and intensity of drought likely to increase or decrease? How might projected changes of climate

because of increasing concentrations of greenhouse gases alter climate variability and the incidence of extreme climate events? There is considerable uncertainty surrounding the debate on these issues (Houghton et al., 1990). It is important to note, however, that the impacts of drought are the product of both the natural event and the vulnerability of society to extended periods of precipitation deficiency. In other words, should drought be defined by the natural event (i.e., the intensity, duration, and spatial extent of meteorological drought), the impacts of that natural event, or both? In our view, since physical and social factors determine risk, both should define drought. Therefore, the impacts that result from future drought occurrences will be determined not only by the frequency and severity of meteorological drought but also by the number of people at risk and their degree of vulnerability.

Available statistics on natural disasters indicate that societies are becoming more vulnerable to drought and other natural hazards. The number of drought-related disasters reported globally increased from 62 during the 1960s to 237 during the 1980s (Blaikie et al., 1994). It is worth mentioning that this total includes droughts associated only with appeals for assistance to donor governments, international organizations, or nongovernmental organizations. Many droughts (e.g., the recent droughts in the United States, Canada, Australia, United Kingdom, and Spain) are not included in this total.

Worldwide, economic damages attributed to natural disasters have tripled in the last three decades, from an estimated \$40 billion in the 1960s to \$120 billion by the end of the 1980s (Domeisen, 1995). It is estimated that the number of people vulnerable to natural disasters is increasing at a rate of about 10 million per year (International Federation of the Red Cross and Red Crescent Societies, 1995). Until 1987, only one natural disaster had resulted in losses exceeding \$1 billion. Since 1987, there have been thirteen such disasters (Domeisen, 1995). This figure does not include drought-induced disasters; these are often excluded from the assessments because of their slow-onset character and nonstructural impacts. However, drought frequently results in costs and losses in excess of \$1 billion in the United States (Riebsame et al, 1990) and elsewhere.

Responding to Drought

Until recently, little effort had been devoted to drought preparedness in the United States. Governments instead relied on the traditional reactive or crisis management approach. Strategies for responding to and preparing for drought are numerous and range from household or community level to regional or national level. These strategies take many forms. At the local level, people and communities possess detailed knowledge of the likely occurrence of drought and its effects and have developed a broad range of strategies over the years to help them reduce its effects and promote recovery once the rains have returned.

At the state or national level, governments may respond to drought in three ways: pre-drought mitigation programs for impact reduction; post-drought relief programs to provide emergency assistance to victims; and preparedness or contingency planning to develop institutional capacity to respond in a more timely and effective manner and reduce impacts (Parry & Carter, 1987). Mitigation is defined as short- and long-term actions or

programs implemented before drought that reduce the degree of economic, social, and environmental risk to people, property, and productive capacity. These activities are long-term preventive or anticipatory measures. Examples of pre-drought mitigation programs include development of an early warning system, augmentation of water supplies, demand reduction, and crop insurance. Post-drought interventions refer to those reactive programs or tactics implemented by government and others in response to drought. This includes a wide range of emergency measures such as low-interest loans, transportation subsidies for livestock and livestock feed, water transport, and drilling wells for irrigation and public water supplies. This reactive, crisis management approach has been criticized by scientists, government officials, and many relief recipients as inefficient, ineffective, and untimely (GAO, 1979; Wilhite et al., 1986; Riebsame et al., 1990; Wilhite, 1993a). More recently, the provision of emergency assistance or relief has been criticized as being a disincentive to the sustainable use of natural resources because it does not promote self-reliance (White et al., 1993; Bruwer, 1993). In fact, this approach may increase vulnerability to drought. Preparedness actions refer to the development of policies and plans that can be useful in addressing future episodes of drought. These policies and plans build institutional capacity to anticipate potential problems, coordinate information flow and decision making, and implement programs to reduce impacts.

Deficiencies that have been noted in the reactive or crisis management approach in the United States and elsewhere include (Wilhite, 1992a):

- the lack of a monitoring system to provide early warning of developing drought conditions;
- inadequate tools and methodologies for early estimation of impacts in various sectors;
- insufficient information flow within and between levels of government on drought severity, impacts, and appropriate policy responses;
- inappropriate or untimely emergency assistance programs;
- poorly targeted emergency assistance programs that do not reach vulnerable population groups and economic sectors;
- lack of emphasis on proactive mitigation programs aimed at reducing vulnerability to drought;
- institutional deficiencies that inhibit effective emergency response; and
- lack of coordination of policies and programs within and between levels of government.

Drought policies and plans must address each of these issues if progress is to be made in drought management during the remainder of this decade and beyond.

State-Level Drought Planning in the United States

The number of states with drought plans has grown from 3 in 1982 to 28 in 1996. In addition, 5 states (Oklahoma, Alabama, Louisiana, Texas, and New Mexico) are now pursuing

drought during both the 1930s and 1950s. In 1976–77, a severe drought, mainly during the winter months, had an immense impact on the state, particularly the state's skiing industry, causing severe economic impacts statewide. When drought conditions again developed during the spring and summer of 1981, the governor initiated the development of a comprehensive state drought plan. The plan has been updated twice, in 1986 and 1990 (Colorado Office of Emergency Management, 1990). Maintaining an effective drought plan is important, as a rapidly growing population continues to increase demands on Colorado's water resources.

The Colorado plan is effective because it incorporates three primary components: a monitoring system, an impact assessment system, and a response system. The responsibility for monitoring the availability of water resources is given to the Water Availability Task Force. This task force makes monthly assessments and projections of snowpack, soil water levels, reservoir and ground water levels, precipitation, temperatures, and stream flow collected by numerous state and federal agencies. This information can provide "early warning" of developing drought conditions to help the state prepare for a potential drought situation. Activation of the drought plan is triggered by the values of two drought severity indices: Palmer Drought Severity Index (PDSI) and the Surface Water Supply Index (SWSI)² calculated for nine river basins across the state (Shafer & Dezman, 1982). A third index based on precipitation alone, the Standardized Precipitation Index (SPI) (McKee et al., 1993), has also been used recently as part of this statewide monitoring system. The SPI can be calculated for multiple time scales. It is calculated by taking the difference of the precipitation from the mean of the particular time scale (e.g., 3-, 6-, 12-months) and then dividing it by the standard deviation. This index has proved useful in communicating information on the spatial and temporal dimensions of drought to a diverse audience.

The assessment system of the drought plan comprises eight different impact task forces covering the following water-related areas: municipal water, wildfire protection, agricultural industry, tourism, wildlife, the economy, energy loss, and health. The goal of each task force is to identify existing and potential drought-related problems and assess possible impacts on society. Each task force is activated based on criteria specifically identified within the plan. Members of the task force are representatives from agencies directly involved with the issue. A final task force, called the Review and Reporting Task Force, is responsible for coordinating all assessments from the impact task forces and reporting this information to policy makers, media, and others.

Finally, the response system is designed to deal with the unmet needs identified by the specific task forces. Local responses are initially encouraged. State action is taken, however, when local capabilities are exceeded. The agency most closely associated with the response is assigned to take action and enlist the cooperation of other agencies. These lead agencies are identified in the plan. For complex emergency responses, an Interagency Coordinating Group is established.

Colorado has determined that it is important to have specific criteria established and responses clearly identified so that as a drought begins, the state can immediately begin to cope with the situation. Colorado's drought plan also calls for a postdrought evaluation.

Suggestions made in these evaluations can be incorporated into the plan to help mitigate the impacts from future drought.

State Drought Mitigation Tools

A recent study reviewed and evaluated ongoing and developing federal, interstate, and state drought mitigation technologies, programs, and policies in the United States (Wilhite, 1993b). This study was based on the assumption that the roles of federal and state governments in drought mitigation needed to be reexamined, given the severity of drought that the United States had experienced since 1986; the economic, social, and environmental costs associated with these droughts; and the mitigation actions and policy efforts underway at all levels of government. One of the goals of the study was to identify opportunities to improve the effectiveness of drought mitigation efforts by the Natural Resources Conservation Service of the U.S. Department of Agriculture and other federal agencies. It was believed that the nation's ability to cope with and manage water shortages resulting from drought would only be improved if an integrated approach within and between levels of government, involving regional organizations and the private sector where appropriate, were adopted.

One of the objectives of this study was to identify emerging drought prediction, assessment, and mitigation technologies that were being employed by various levels of government to lessen the effects of future severe droughts. Increasing demand for water throughout the United States and the widespread occurrence of drought resulted in the introduction of numerous innovative institutional technologies to manage water more effectively and efficiently during periods of shortage. The goal of this objective was to identify the lessons learned from these institutional adjustments and the specific constraints that exist to the implementation of other drought mitigation programs, including the development of drought preparedness plans.

Data on drought mitigation actions were collected through a survey of states and key federal agencies with responsibility in the management of water and other natural resources during periods of drought. The survey was directed at specific actions taken or programs adopted during the period from 1986 to 1992, a particularly drought-affected period (see figs. 2 and 3).

Mitigative actions were purposely not defined in the survey instrument referred to above—states were given the flexibility to define mitigation by including those actions or activities that they felt were appropriate. Those mitigation activities identified by states and/or local municipalities during recent droughts were diverse, reflecting regional differences in impacts, legal and institutional constraints, and characteristics of contingency plans. The diversity in responses was also related to the wide range of state agencies with principal authority for planning and mitigative actions (e.g., agriculture, natural resources, water resources, emergency or disaster management).

State mitigation actions used to address issues during recent droughts are clustered into nine primary areas in table 1. These actions represent the full range of possible mitigative actions, from monitoring and assessment programs to the development of drought contingency plans. Some of the actions included were adopted by many states, while others may

have been adopted only in a single case. One of the most innovative and successful mitigation actions implemented during recent droughts was the California Drought Water Bank Program (California Department of Water Resources, 1992). This program was created in 1991 and could acquire water in three ways: (1) by purchasing water from farmers who did not irrigate, choosing to allow water to flow past their farms; (2) by purchasing surplus water from local water districts; and (3) by paying farmers or water districts to use ground water instead of surface water.

Table 1. Drought-related mitigative actions taken by states during recent droughts

Category	Specific action
Assessment Programs	Developed criteria or triggers for drought-related actions Develop early warning system, monitoring program Conduct inventories of data availability Established new data collection networks Monitored vulnerable public water suppliers
Legislation/Public Policy	Prepared position papers on public policy issues Examined water rights statutes for possible modification during water shortages Passed legislation to protect instream flows
Water Supply Augmentation/ Development of New Supplies	Issued emergency permits for water use Provide pumps and pipes for distribution Proposed and implemented program to rehabilitate reservoirs to operate at design capacity Undertook water supply vulnerability assessments Inventoried self-supplied industrial water users for possible use of their supplies for emergency public water supplies Inventoried and reviewed reservoir operation plans
Public Awareness/ Education Programs	Organized drought information meetings for the public and the media Implemented water conservation awareness programs Published and distributed pamphlets to individuals, businesses, and municipalities on water conservation techniques and agricultural drought management strategies Organized workshops on special drought-related topics Prepared sample ordinances on water conservation for municipalities and domestic rural supplies
Technical Assistance on Water Conservation	Provide advice on potential new sources of water Evaluated water quantity and quality from new sources Advised water suppliers on assessing vulnerability of existing supply system Recommended the adoption of water conservation measures to suppliers
Demand Reduction/ Water Conservation Programs	Established stronger economic incentives for private investment in water conservation Encouraged voluntary water conservation Improved water use and conveyance efficiencies Implemented water metering and leak detection programs
Emergency Response Programs	Established alert procedures for water quality problems Stockpiled supplies of pumps, pipes, water filters, and other equipment

	<ul style="list-style-type: none"> Establish water hauling programs for livestock from reservoirs and other sources Compiled list of locations for livestock watering Established hay hotline Provided funds for improvement of water systems, developing new systems, and digging of wells Provide funds for recovery programs for drought and other natural disasters Lowered well intakes on reservoirs for rural water supplies Extended boat ramps and docks in recreational areas
Water Use Conflict Resolution	<ul style="list-style-type: none"> Acted to resolve emerging water use conflicts Negotiated with irrigators to gain voluntary restrictions on irrigation in areas where domestic wells were likely to be affected Establish a water banking program Clarified state law regarding sale of water Clarified state law on changes in water rights Suspended water use permits in watershed with low water levels Investigated complaints of irrigation wells interfering with domestic wells
Drought Contingency Plans	<ul style="list-style-type: none"> Recommended to water suppliers the development of drought plans Establish state-wide contingency plan Evaluated worst-case drought scenarios for possible further actions

Many of the mitigative programs implemented by states during recent droughts can be characterized as emergency or short-term actions taken to alleviate the crisis at hand, although these actions can be successful, especially if they are part of a preparedness or mitigation plan. Other activities, such as legislative actions, drought plan development, and the development of water conservation and other public awareness programs, are considered actions with a longer-term impact. As states gain more experience assessing and responding to drought, future actions will undoubtedly become more timely and effective and less reactive. Mitigative actions taken by states in response to recent drought conditions are numerous when considered in total, but most individual state actions were quite narrow. In the future, state drought contingency plans need to address a broader range of potential mitigative actions, including provisions for expanding the level of intergovernmental coordination. Improved coordination will require a greater commitment by federal agencies to work together and with states to promote an integrated approach to drought planning. Coordination at the federal level will likely require the establishment of an interagency task force, as recommended by the Congressional Office of Technology Assessment (1993).

Federal Drought Response and Planning

The federal government became the principal player in the provision of drought relief in response to the economic depression and droughts of the 1930s (Wilhite, 1983). Before that, assistance was provided primarily by the private sector (e.g., churches, Red Cross). The level of assistance required during the 1930s far exceeded the capacity of this sector to respond. The federal government was the principal provider of drought assistance during

subsequent drought events, most notably the 1950s in the southwest, southern plains, and midwestern states; the 1960s in the northeast; the mid-1970s in the midwest and western states; and the recent series of drought years beginning in 1986. Until recently, state government and the private sector assumed a relatively passive role in drought management. Drought relief remains largely a federal responsibility.

Post-drought evaluations or audits are not routinely completed in the United States. However, the General Accounting Office (GAO) characterized the assessment and response programs implemented in the mid-1970s as largely ineffective, poorly coordinated within and between levels of government, and untimely. GAO (1979) found that assistance provided by federal agencies to farmers, communities, businesses, and water user organizations was available too late to lessen the effects of drought. Wilhite et al. (1986) confirmed these findings and also concluded that the decision-making process was seriously flawed. For example, the designation and revocation process for determining eligibility for the more than \$5 billion of disaster relief expended in 1976–77 was confusing and was not based on consistent, established criteria. In total, 16 federal agencies administered 40 separate assistance programs in 1976–77. GAO (1979) recommended a national drought plan be developed to provide "future assistance in a more timely, consistent, and equitable manner." GAO further recommended that the plan address the following issues: (1) the identification of respective roles of agencies involved to avoid overlap and duplication, (2) the need for legislation to more clearly define those roles, and (3) the need for standby legislation to permit more timely response to drought-related problems. GAO suggested that effectively implementing a national plan required establishing uniform criteria for determining "priorities for the type of projects to be constructed; eligibility of applicants; and interest rates, terms, and repayment requirements for loans."

Wilhite et al. (1986) concluded that four basic requirements were necessary for federal government to improve response to drought. These were (1) reliable and timely information and dissemination plans, (2) objective and reliable impact assessment procedures, (3) objective and timely designation (and revocation) procedures, and (4) appropriate disaster programs and efficient program administration and delivery systems. It was concluded that a national drought plan would help coordinate the activities of the federal government in mitigating the effects of future droughts. It was also suggested that state government and regional organizations should play a more active role in drought management and that those activities be coordinated between levels of government.

Following the severe droughts of 1976–77 and the demonstrated inability of the federal government to adequately cope with the problems that emerged, scientists and policy makers expressed considerable concern about the inefficiencies of this effort and repeatedly issued "calls for action" for the development of drought contingency plans, including the development of a national drought plan. These calls included recommendations from the Western Governors Policy Office (1978), General Accounting Office (1979), National Academy of Sciences (1986), Great Lakes Commission (1990), American Meteorological Society (Orville, 1990), and Interstate Council on Water Policy (1987; 1991). In light of a possible increase in the frequency and severity of extreme events in association with changes in climate, an Environmental Protection Agency report (Smith & Tirpak, 1989) called for the development of a national drought policy to coordinate federal response to

drought. The intent of a national drought policy is to move the country away from a reactive, crisis management approach toward a proactive, risk management approach.

To date, no progress has been made at the federal level on the development of a national plan. Federal efforts to respond to the series of droughts between 1987 and 1989 proved to be only slightly, if any, better than previous attempts (Riebsame et al., 1990). As a direct result of the droughts of the late 1980s and early 1990s, a few federal agencies initiated changes in policies and programs, but coordination between agencies continues to be largely nonexistent. The Corps of Engineers' National Water Management During Drought Study and the Bureau of Reclamation's new strategic plan are excellent examples of individual agency efforts to improve drought response.

Drought Policy: A Plan of Action

Drought policy in the United States has not been stated explicitly by the federal government. What has evolved since the 1930s has been a de facto policy, one of reacting to, rather than preparing for, periods of water shortage. This crisis management approach, as discussed previously, has been ineffective. Unfortunately, the decision on whether to provide drought relief has been based more often on political rather than economic reasoning. Without a clearly stated drought policy, it is unlikely that significant improvement will occur in federal response efforts in the United States. Drought relief or assistance, if necessary, must be provided only if it is consistent with stated national policy. This policy would provide the framework for a national drought plan; incentives could be given to states to make their plans consistent and compatible with national goals.

Although governments in the United States have shown some progress in responding to recent droughts, the dilemma facing government, particularly the federal government, is whether to continue with the approach of the past (i.e., crisis management) or seek a new direction. Given that previous attempts to mitigate drought in the United States have been largely unsuccessful, it seems clear that fundamental and sweeping program and policy changes must occur in order for the nation to more adequately address the drought management problems that exist today and will exist in the future. As a nation we can no longer afford to tinker with a system that is seriously flawed.

A wide range of risk reduction measures exist that the federal government could implement to lessen vulnerability to drought in the United States (Wilhite, 1992b; U.S. Congress, Office of Technology Assessment, 1993). These measures are divided into five categories in table 2. Improved assessment programs cover a broad range of initiatives that seek to improve the capacity of governments to monitor water availability. Current monitoring programs are fragmented between federal agencies and levels of government, inconsistent from region to region, and poorly coordinated. In addition, near-real time assessments of soil moisture conditions, a critical variable in early estimation of crop yield potential and other evaluations, are piecemeal at best. A comprehensive, integrated national drought (or climate) assessment system would rectify these problems.

Table 2. Recommended risk management and risk minimization measures that the federal government in the United States should consider to lessen the effects of drought	
Category	Specific action
Assessment Programs	<ul style="list-style-type: none"> Develop a comprehensive, integrated national drought watch system (NDWS) Inventory data availability in support of a NDWS Improve existing and establish new data collection networks (e.g., soil moisture, A VHRR) Develop new indexes to assist in the early estimation of impacts in various sectors Establish objective "triggers" for the phase-in and phase-out of relief/assistance programs
Legislation/Public Policy	<ul style="list-style-type: none"> Develop a national drought policy and plan Examine federal land use policies to ensure appropriate management of natural resources and consistency with national drought policy Promote a reexamination of state water rights statutes for possible modification Review all federal drought relief/assistance programs, federal crop insurance program, and other agricultural/water policies for consistency with national drought policy
Water Supply Augmentation/ Development of New Supplies	<ul style="list-style-type: none"> Promote vulnerability assessments of public water supply systems Review reservoir operation plans for improved management of water supplies during drought Improve operational flexibility of water allocations between users Establish stronger economic incentives for private investment in water conservation Promote improved water use and conveyance efficiencies Promote the implementation of municipal water metering and leak detection programs
Public Awareness/ Education Programs	<ul style="list-style-type: none"> Establish a national drought mitigation center to provide information to the public and private sectors Improve data/information products and delivery systems to provide timely and reliable information to users Develop and implement water conservation awareness programs
Drought Preparedness Planning	<ul style="list-style-type: none"> Promote the establishment of comprehensive state drought plans Promote intergovernmental cooperation and coordination on drought planning Evaluate worse-case scenarios for drought management Evaluate the potential effects of climate change on regional hydrology and its implication on federal and state water policies Promote the establishment of drought plans by public water suppliers Conduct post-drought audits of federal drought assessment and response efforts

In the domain of public policy, a national drought policy and plan could profoundly enhance governmental capacity to lessen the risk of future events. The development of a policy would require a reexamination of federal land use policies and current federal drought assistance programs, including crop insurance, and other agricultural and water policies for consistency. A national policy could also promote a thorough reexamination of water rights through the provision of incentives to states. Tackling the issue of water

rights is critical to the adoption of a proactive approach to drought management. Many states have initiated changes in water rights, a process that must continue if the nation is to adjust to current and future water use trends and deal more effectively with conflicts between users for an increasingly scarce resource.

From a management perspective, there are many opportunities to increase water availability through demand management. Significant savings can be achieved through well-designed water conservation programs, improved conveyance efficiencies, metering and leak detection programs, and modification of reservoir operation plans. States should also conduct vulnerability assessments of public water supply systems to determine the sensitivity of these systems to extended periods of water shortage and promote programs to reduce that sensitivity.

One of the deficiencies noted by many decision makers has been the lack of or untimeliness of relevant information on drought conditions and appropriate response options or mitigation measures that could be employed (Wilhite & Wood, 1994). Public awareness programs are useful in this regard, but there is also a continuing need to consolidate and centralize information to facilitate availability and distribution. In 1995, the National Drought Mitigation Center was established at the University of Nebraska–Lincoln with one of its principal goals to develop a comprehensive drought information clearinghouse.³

The rapid increase in the number of state drought plans has improved the ability of states to detect emerging drought conditions, estimate potential impacts, and formulate a variety of response measures to reduce hardships and impacts. Drought preparedness can be fostered further through the adoption of mitigation measures that are directed at reducing impacts, such as those programs or measures included in table 1. Post-drought audits are critical in identifying the successes and failures of previous response efforts. Such audits are rare in the United States at either the state or federal level. Without a systematic post-drought evaluation effort, the deficiencies of previous responses are often repeated. It is also important to coordinate drought plans between levels of government. For example, municipal drought or water shortage plans should be coordinated with state plans; river basin or reservoir operation plans should be coordinated with state-level plans that exist within the basin. Coordination of drought planning at multiple administrative levels provides a strong rationale for the adoption of a national drought policy or philosophy that establishes the principles for the sustainable use of natural resources.

Conclusions and Recommendations

During the past decade in the United States, widespread and severe drought has resulted in an increased awareness of the nation's continuing vulnerability to this creeping natural hazard. This experience has resulted in numerous initiatives by state and federal governments to improve the timeliness and effectiveness of response efforts. Although some progress has been made, much remains to be done. For the most part, governments continue to deal with drought in a reactive, rather than proactive, mode. The growth in the number of states with drought plans is one positive sign that greater emphasis is now being placed on drought preparedness, although most state responses continue to stress emergency assistance. States have developed and implemented a wide range of mitigation measures but

the shift from crisis management to risk management continues to be a difficult transition for governments.

For this transition to be successful, the deficiencies of previous drought response attempts noted in this chapter must be addressed in a systematic way. Creating a federal interagency task force with the authority to develop and implement a national drought policy and plan would represent an important first step. The task force must develop the objectives of an integrated national policy in concert with extensive public involvement. This policy should promote the concept of risk management, although the policy cannot ignore the need for government assistance during extended periods of severe drought. The policy should promote self-reliance while at the same time protecting the natural and agricultural resource base. This interagency task force should coordinate the drought-related activities of the federal government (i.e., forecasting, monitoring, impact assessment, response and recovery, and planning), linking these activities to state and regional planning activities and plans. This national policy should also incorporate incentives for all drought-prone states to develop plans that promote a more proactive, anticipatory approach to drought management. Lessons learned from previous drought response attempts need to be documented, evaluated, and shared with all levels of government.

Drought inflicts considerable pain and hardship on society. The impacts of contemporary droughts in the United States have demonstrated this fact again and again over the past several decades. Drought illustrates in innumerable ways the vulnerability of economic, social, political, and environmental systems to a variable climate. It also illustrates the dependencies that exist between systems, reinforcing the need for improved coordination within and between levels of government.

Extended periods of normal or benign weather conceal the vulnerability of societies to climate variability, while drought exposes these sensitivities. Projected changes in climate because of increased concentrations of carbon dioxide and other atmospheric trace gases suggest a possible increase in the frequency and intensity of severe droughts in the future. Coupled with the world's increasing population and associated rise in demand for water and other shared natural resources, there is a sense of urgency to reduce drought-inflicted personal hardships, as well as economic and environmental impacts of drought.

Drought is a good analog for climate change because it helps identify societal strengths and weaknesses in coping with extreme climatic events today, thus allowing us to bolster the strengths and sharply reduce or eliminate the weaknesses in the future. Stated another way, drought first exposes vulnerabilities to climate variability and then provides us with the opportunity to adjust or adapt present systems to be more in harmony with the stresses imposed by that variability. Drought planning is the tool to accomplish this goal.

Notes

1. The PDSI compares quantitatively the actual amount of precipitation received during a specific period with the normal amount expected during that same period. The PDSI is based on a procedure of hydrologic or water-balance accounting by which excesses or deficiencies in moisture are determined in relation to average climatic values. It is the most commonly used index in the United States.

2. Designed to complement the PDSI, the SWSI is an indicator of surface water conditions in which mountain snowpack is a major component. The SWSI incorporates four hydrological and meteorological inputs: snowpack, streamflow, precipitation, and reservoir storage.
3. For more information on the National Drought Mitigation Center, consult the NDMC's home-page (<http://enso.unl.edu/ndmc>) on the World Wide Web.

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