FEATURE

The role of water conservation in drought planning

Cody L. Knutson

Drought is a natural part of climate in most regions around the world. We should not be surprised when drought occurs but expect and account for it in our management plans. Yet, every year, severe drought occurs somewhere in the United States, resulting in millions, if not billions, of dollars in financial drought losses and untold stress on people, businesses, and the environment.

Although many livelihoods and sectors are relatively resilient to short-term drought, there are times when exceptional drought circumstances undermine our usual management strategies. Historically, when this has happened, governments and other decision makers have implemented a wide range of ad-hoc drought relief measures to get through the hard times. Although often providing important emergency assistance, these crisis management efforts are frequently highly political, untimely, inefficient, and poorly targeted (Wilhite et al. 2005).

To address these issues, a new paradigm has emerged among drought and other hazard planners that focuses more attention on implementing proactive risk management strategies before a disaster occurs. Planners are increasingly developing drought mitigation and preparedness plans to increase a region's or sector's long-term resiliency to drought and to help ensure the implementation of appropriate and well-coordinated response actions during drought. Water conservation plays an important role in both increasing our resiliency to drought and responding to drought crises.

WHAT'S AT STAKE

Although specific definitions of drought may vary by sector and region, drought generally originates from a significant deficiency of precipitation from "normal" over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector (Knutson et al. 1998). This is different from a water shortage caused by other human-induced or environmental causes, such as faulty infrastructure or poor water management.

On average, severe to extreme drought affects approximately 14% of the United States every year (Wilhite and Buchanan-Smith 2005). However, at the height of the especially severe drought year of 2002, as much as 55% of the United States experienced moderate to exceptional drought conditions, and another 16% was reported to be experiencing abnormally dry conditions (figure 1). As of late April 2008, drought and dry conditions were still affecting nearly 48% of the United States (figure 2).

Recent droughts in the United States continue to reveal a wide variety of vulnerable environmental and socioeconomic interests. In fact, the US Department of Commerce's National Climatic Data Center has recorded 13 drought years in the United States from 1980 to 2007 that have exceeded \$1.0 billion in damages/costs (table 1). The total cost for the droughts and associated heat waves is nearly \$157 billion (in 2007 dollars). Although a rough estimate, this represents an annual average of at least \$5.6 billion dollars in direct drought losses, primarily in the agricultural sector.

However, these financial losses do not typically include other drought-related impacts such as water and energy or tourism-related losses, stress on families and communities, or the toll drought can take on the environment (see figures 3 to 6). To help safeguard livelihoods and the environment, and reduce the likelihood of future losses, planners are increasingly implementing a risk management approach to drought.

CRISIS VERSUS RISK MANAGEMENT

When operating within the crisis management paradigm, once drought conditions become apparent, decision makers typically implement a series of measures to help alleviate the negative effects of drought. In many cases, these are ad hoc measures targeted to vulnerable populations, the environment, and other sectors that are already being affected. This is largely a reactive disaster management strategy. Although crisis management is an important component of the disaster management cycle, planners are becoming more aware of the potential cost savings and reduction of impacts on people and their livelihoods that can be realized by embracing a risk management approach.

The risk management paradigm revolves around the concepts of mitigation and preparedness (figure 7). In the case of drought, according to the United Nations International Strategy for Disaster Reduction (2007), mitigation refers to any structural/physical measures (e.g., appropriate crops, engineering projects) or nonstructural measures (e.g., policies, awareness, knowledge development, public commitment, operating practices) undertaken to limit the adverse impacts of drought. Preparedness is defined as established policies and specified plans and activities taken before drought to prepare people and enhance institutional coping capacities, to forecast or warn of approaching dangers, and to ensure coordinated and effective response in a drought situation (i.e., contingency planning).

Today, decision makers are increasingly focusing more attention on the risk management portion of the disaster cycle. The thinking behind this paradigm shift is reflected in Benjamin Franklin's famous quote that "an ounce of prevention is worth a pound of cure." Reducing the likelihood of experiencing drought-related impacts, or the severity of them, before a crisis occurs is just using good common sense.

It may also make solid financial sense, according to a study funded by the Federal Emergency Management Agency and carried out by the Multihazard Mitigation Council (2005). The study found that every dollar spent by the Federal Emergency Management Agency on grants for earthquake, wind, and flood hazard mitigation provides the nation

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Figure 1

US drought monitor map for September 10, 2002 (http://www.drought.unl.edu/DM/).

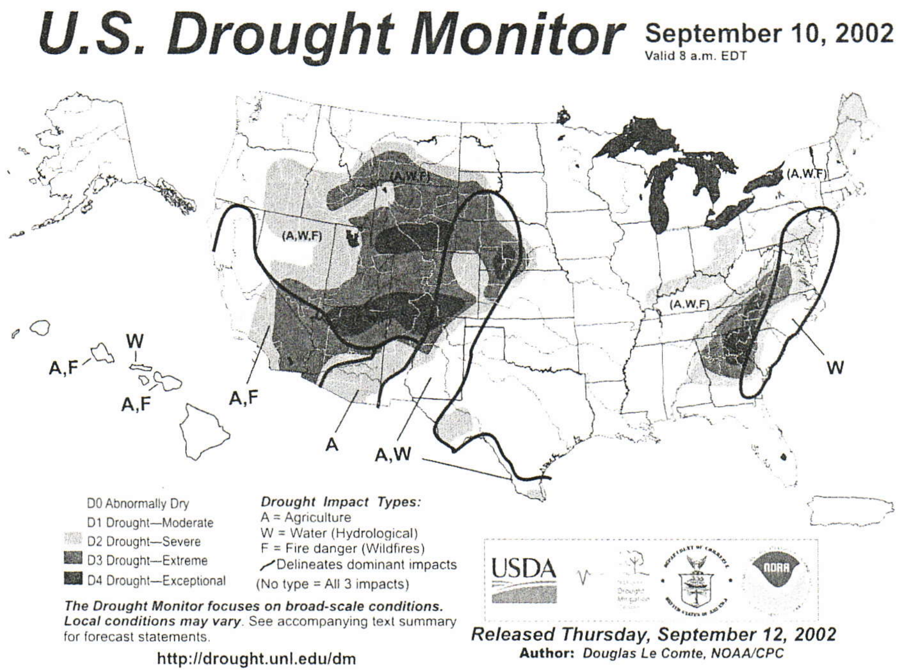


Figure 2

US drought monitor map for April 29, 2008 (http://www.drought.unl.edu/DM/).

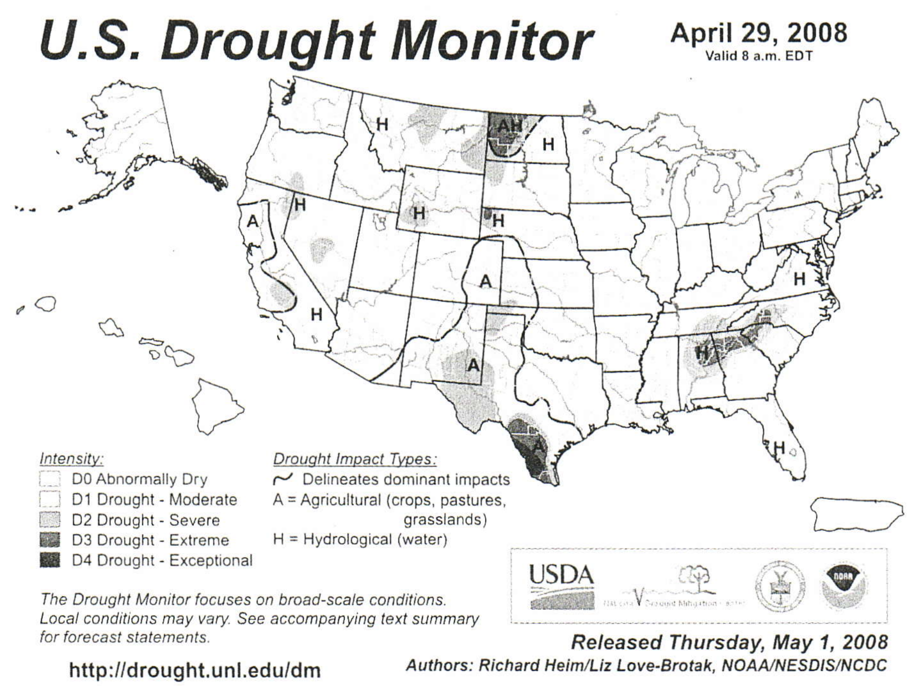


Table 1

Estimated annual drought losses in the United States (National Climatic Data Center 2008).

Year	Region affected	Monetary losses (billions in 2007 dollars)
2007	Great Plains and eastern states	$5.0
2006	Great Plains, South, and far West	$6.2
2005	Midwest	$1.1
2002	Widespread	$10.0
2000	Southcentral and southeastern	$4.2
1999	Eastern	$1.1
1998	Southern	$8.25
1996	Southern Plains	$6.0
1993	Southeastern	$1.3
1989	Northern Plains	$1.5
1988	Central and eastern	$61.6
1986	Southeastern	$2.2
1980	Central and eastern	$48.4
Total		**$156.9**

with approximately $4 in avoided future losses. In general, the study concluded that "mitigation is sufficiently cost-effective to warrant federal funding on an ongoing basis both before disasters and during post-disaster recovery. The nation will always be vulnerable to natural hazards; therefore, it is only prudent to invest in mitigation" Although specific studies are limited, it is likely that similar benefits could be accrued through the implementation of drought mitigation measures.

The most appropriate mitigation and preparedness actions for a particular sector can be identified by undertaking a drought planning process. The number of states, tribes, water districts, communities, agricultural producers, and others that are developing drought plans has increased dramatically in the last two decades. For example, in 1983, only 3 states had a drought plan. By 2008, that number had grown to 37 states. Most of these plans focus on drought response activities, but a growing number also include predrought mitigation actions.

Similarly, several tribal governments in the western United States (i.e., the Hopi Tribe, Hualapai Nation, Navajo Nation, San Carlos Apache Tribe, Tohono O'odham Nation, and Zuni Pueblo in Arizona and New Mexico; Fort Peck Tribes and Northern Cheyenne Tribe of Montana) have also undertaken efforts to develop innovative drought mitigation and response plans (Knutson et al. 2007).

Many communities, river basin authorities, and individual agricultural producers have also joined the drought planning trend. Their resulting plans outline predrought mitigation actions that can be implemented to build resilience into an enterprise or system so it will be less affected when drought eventually occurs,

Figure 3

By May 2008, Lake Mead had been drawn down to 48% of capacity from successive years of drought. Photo by Cody Knutson, National Drought Mitigation Center.

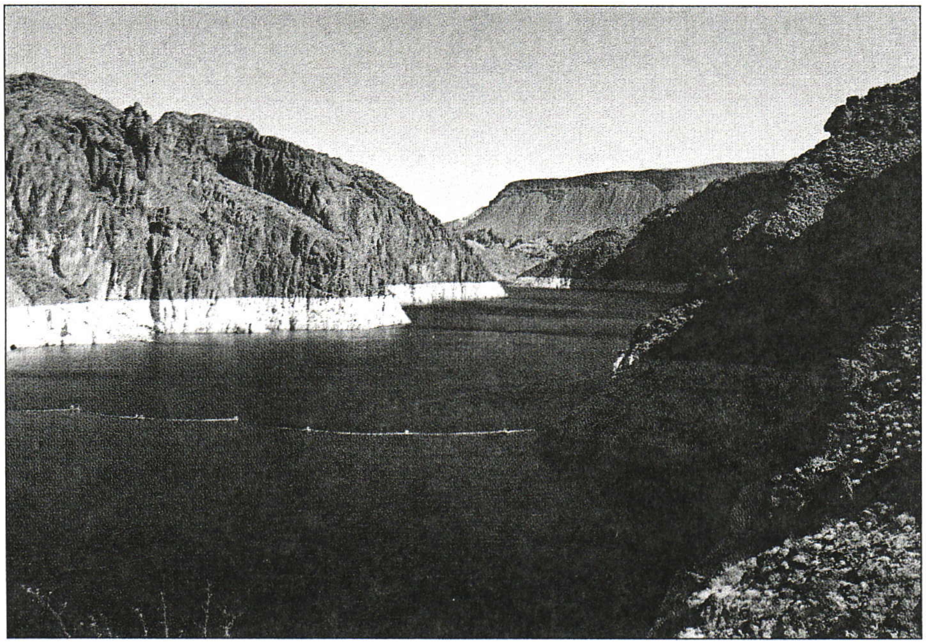


Figure 4

Pontoons were stranded by drought-related low water levels on Lake Moultrie, South Carolina. The drought from 1998 to 2002 significantly affected tourism in the region. Photo by Cody Knutson, National Drought Mitigation Center.

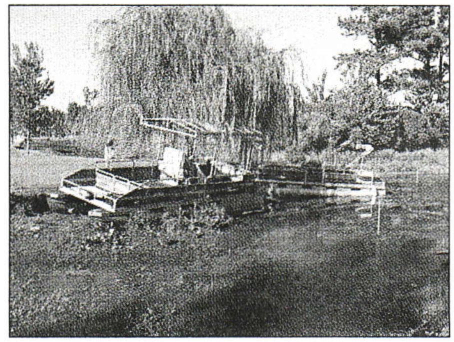


Figure 5

A combination of drought and grasshoppers destroyed corn and other crops in Nebraska during 2002, causing an influx of mental health counseling requests. Photo by Brian Fuchs, National Drought Mitigation Center.

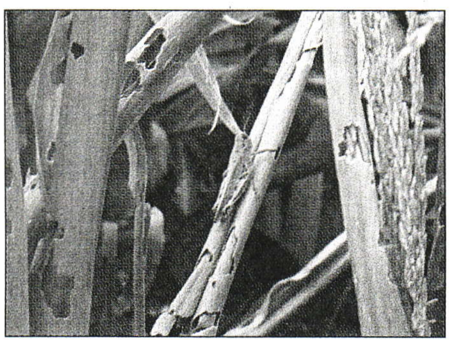
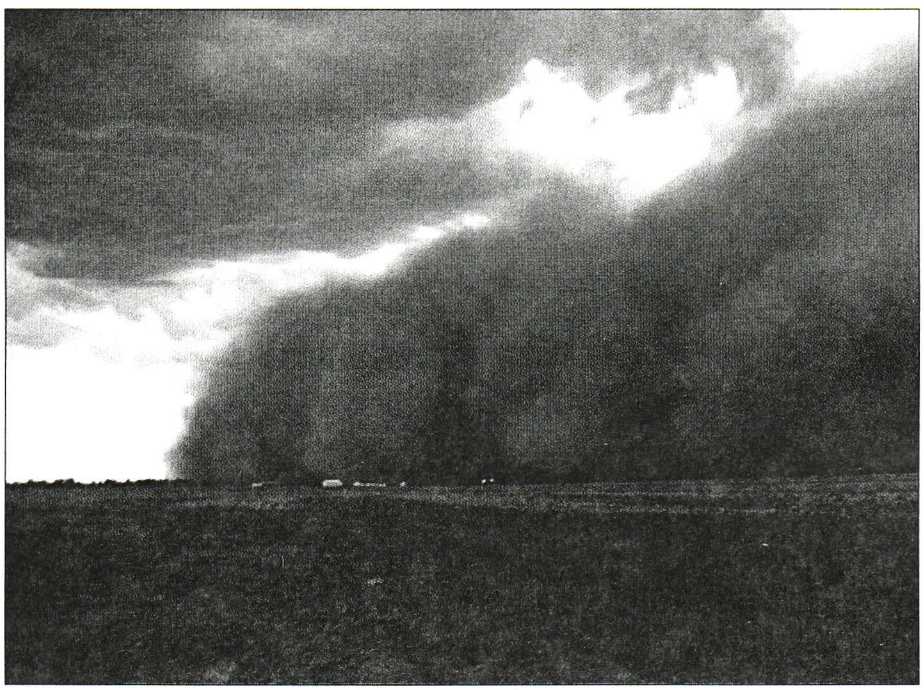


Figure 6

Dust storm overtaking the town of Colby, Kansas, on May 29, 2004. Dust storms have occurred during recent years in drought-stricken states such as Texas, Kansas, Colorado, and Montana. Photo courtesy of Robert Grace, Grace Flying Service, St. Francis, Kansas.



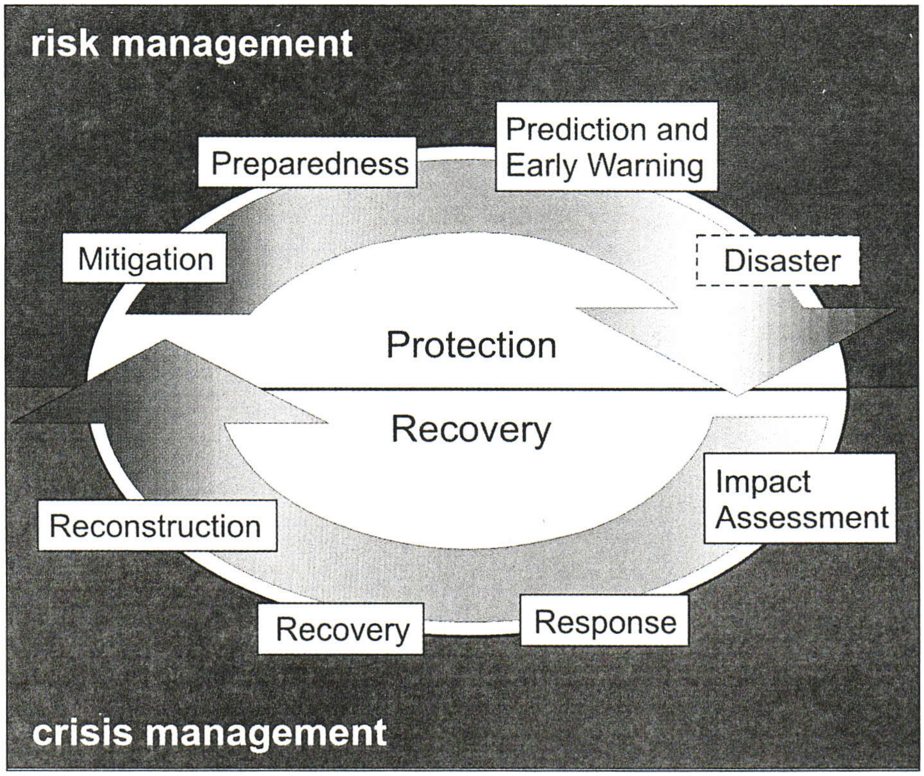
as well as specific measures that can be taken by individuals or responsible agencies during and after drought. Some of these actions require relatively small changes in our lives; others may require the reevaluation and modification of more basic elements of our livelihoods and production systems.

ROLE OF WATER CONSERVATION

A broad range of potential mitigation and response actions could be implemented to reduce drought risk. In terms of water management, many of the options involve either augmenting water supplies or reducing water demand—balancing supply and demand. As for augmenting water supplies, much of the developed world's freshwater sources have already been tapped (Vickers 2005), and signs of stress are already apparent in many US water systems that have

Figure 7

Crisis and risk management components of the disaster management cycle. Illustration by Donald Wilhite, National Drought Mitigation Center.



made recent news headlines, such as the Colorado River, the Rio Grande River, the Chattahoochee River, and the Ogallala Aquifer. Although water resources continue to be tapped and redistributed in many locations, the "slack" in our water systems is tightening.

Therefore, emphasis is being placed on reducing water demand through behavioral and technological water conservation measures. Behavioral measures are those that are reliant on the actions of water users, such as taking shorter showers and limiting the amount of water used for lawn watering or car washes. Technological measures include fixing the leaks in water systems or installing low-flow showerheads or more efficient irrigation technology. Although not always the case, behavioral measures tend to be short-term or sporadic (i.e., drought response measures), and technological measures are aimed at reducing the long-term use of water (i.e., drought mitigation measures) (Vickers 2005).

Both types of measures can be used as important drought management tools. There are water conservation devices, technologies, or practices that will save water for every drought vulnerable sector (table 2). For example, public information campaigns that raise awareness of a water shortage have been shown to reduce water use by 5% to 20%, depending on the time, money, and effort spent (California Department of Water Resources 2008). Similarly, a study of eight water suppliers in Colorado during the 2002 drought found that voluntary water restrictions reduced per-capita water use 4% to 12% and mandatory restrictions reduced per-capita water use 18% to 56% (Kenney et al. 2004).

In terms of technological fixes, it is not unusual for a community to lose 10% to 20% or more of its water supply to leaks, thefts, and metering inaccuracies (Lahlou 2001; Scherer 2002). The implementation of enhanced leak detection, monitoring, and management programs could reduce a great deal of these losses. Providing home water audits, free hose nozzles and buckets, rebates for efficient plumbing fixtures and appliances, and gray water information can also reduce residential water use by up to 189 L (50 gal) per capita per day without significant lifestyle changes (California Department of Water Resources 2008).

These efforts are not just limited to urban areas. New irrigation equipment and land management techniques are helping to reduce the demands placed on water resources by the agricultural sector, which is one of the predominant water users in the United States. For example, the average irrigation application rate declined approximately 30% from 1950 to 2000 (Hutson et al. 2004). This decline has largely been credited to an increasing trend away from flood irrigation to more efficient sprinkler and micro-irrigation techniques.

The selection of the most appropriate mixture of water conservation and other drought risk reduction measures can be determined during a drought planning process. For example, the state of Georgia finalized a drought management plan in 2003 (Georgia Department of Natural Resources 2003). During the process, planners identified several water conservation measures (outlined in table 3) to be implemented before and during drought conditions. A similar process can be conducted at any decision-making scale, from an individual business to the state or national level.

When implemented, conservation measures offer great potential for reducing the risk of droughts and water shortages. Technological and management measures can reduce long-term water demand, which can limit the need for emergency response measures during times of drought. However, if water reductions are required during drought, an early warning system with predetermined drought stages and behavioral conservation measures is a necessity for efficient drought management.

Although often causing severe hardships, a drought also offers an opportunity to foster a permanent water-saving culture, or "low water-use lifestyle" (Grenoble 2008). Drought will capture the attention of water users, and public education programs, incentives, and regulations can help turn temporary water conservation behaviors into permanent water savings. These cultural changes may be increasingly important as we deal with future water supply challenges.

Table 2

Water conservation measures and their possible savings (modified from Vickers 2005).

Conservation measures	Possible water savings
Water utilities: System audits, leak detection and repair, metering and meter maintenance, pressure regulation	Varies
Lawn/landscaping: Conservation-oriented rates, rebates, and incentives; water-efficient landscape design; native/drought-tolerant turf and plants; limited/no watering of turf and landscape areas; efficient irrigation devices; rainwater harvesting; leak detection and repair	15% to 100%
Commercial/industrial/institutional: Conservation-oriented rates, rebates, and incentives; efficient cooling and heating systems; water reuse; improved flow controls; efficient fixtures, appliances, and equipment; point-of-use hot water heaters; leak detection and repair	15% to 50%
Residential interior: Conservation-oriented rates, rebates, and incentives; more efficient plumbing fixtures, clothes washers, dishwashers, and hot water heaters; leak detection and repair	10% to 50%
Agricultural: Conservation-oriented rates, rebates, and incentives; metering on-farm water uses; efficient irrigation systems, practices, and scheduling; land conservation methods	10% to 50%

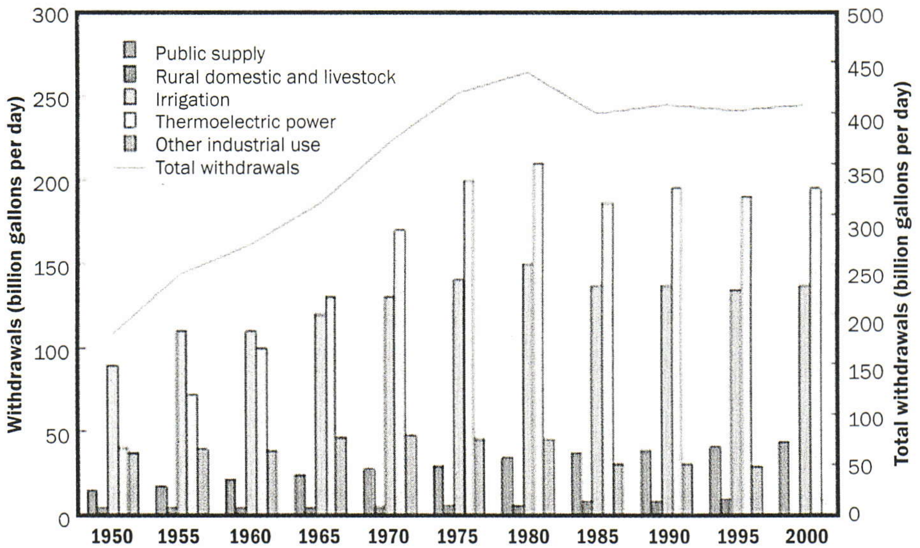
Table 3

Predrought and drought response water conservation practices outlined in the Georgia Drought Plan (modified from Georgia Department of Natural Resources 2003).

Predrought water conservation activities	Proposed drought response water conservation activities
Develop and implement a statewide water conservation program.	Implement and enforce outdoor watering reduction schedules according to drought stages identified in the drought plan.
Review local conservation and drought contingency plans.	Implement conservation pricing options that satisfy water conservation goals.
Encourage all responsible agencies to promote voluntary water conservation.	Encourage increased surveillance for leaks that may be more apparent during drought.
Develop and implement an incentive program to encourage more efficient use of water.	Implement industrial water reduction opportunities to use less water in producing products and services during drought.
Establish criteria for drought-tolerant golf courses.	Run public service announcements about proper watering techniques and frequency.
Encourage water reuse as opposed to additional withdrawals of raw water.	Provide daily evaporation-transpiration rates for irrigation scheduling.
Provide water efficiency education for industry and business.	
Conduct voluntary water audits for businesses.	
Develop criteria for a voluntary certification program for landscape professionals.	
Establish permanent outdoor watering schedules in urban areas.	
Distribute water conservation information to farmers and participation in classes on best management practices and conservation irrigation.	
Encourage the use of more drought-resistant crops, subject to market conditions.	
Encourage the use of innovative cultivation techniques to reduce the amount of water needed or lost by a crop during summer.	
Conduct crop irrigation efficiency studies.	
Retrofit and install new water-efficient irrigation technology.	
Recommend irrigation system efficiency audits every five to seven years.	
Improve on agriculture irrigation water measurement and accounting statewide.	
Recommend and explore providing incentives or requiring installation and use of automatic rain shut-off devices for irrigation systems.	
Providing for and conducting home and farm water conservation audits.	
Providing updated information and incentives for water-efficient landscaping.	
Establishing conservation pricing rate structures.	

Figure 8

Trends in total water withdrawals in the United States by water-use category, 1950 to 2000. From Hutson et al. (2004), courtesy of the US Geological Survey.



A recent issue of the *Journal of Soil and Water Conservation* (Anderson-Wilk 2008) posed some important water resource questions, including "What are realistic expectations for what can be accomplished through conventional and state-of-the-art water conservation measures applied to current land and water uses? In what cases will conservation on its own simply not be enough, and when will significant changes to land use and human activity be required to minimize conflict, loss, and crisis related to water shortages?"

As shown in table 2, current water conservation measures can have a great deal of water-savings potential. In fact, advances in water conservation technologies and behaviors have helped stabilize freshwater withdrawals in the United States since the mid-1980s (figure 8).

However, as populations and demands on our water resources continue to grow, concerns are growing that larger changes may be required to sustain adequate supplies of quality water. For example, the US General Accounting Office conducted a survey of state water managers and found that managers in 36 states, of the 47 that responded, anticipated water shortages in localities, regions, or statewide by 2013 (US General Accounting Office 2003). Under drought conditions, 46 managers expected shortages within the same time span. The survey found that the nation's capacity for storing surface water is limited, groundwater is being depleted, growing populations and pressures to keep water in-stream for fisheries and the environment are placing new demands on the freshwater supply, and the potential effect of climate change creates additional uncertainty about future water availability. The study concluded that, under these conditions, it is even more important to secure the future availability of water for all US citizens and to find equitable ways to achieve this goal.

These circumstances require planners to continue to investigate and apply conventional water conservation strategies but also look ahead to emerging ideas. For example, rainwater harvesting systems are now being required in new homes by the Albuquerque and Bernalillo County Water Utility Authority in Arizona; Las Vegas's Water Smart Landscaping program helped save 6.8×10^{10} L (1.8×10^{10} gal) of water in 2006; the city of Greenville, North Carolina, is developing an aquifer storage and recovery system to store water for times of need; some Nebraska farmers have been paid to switch from irrigated to dryland farming; and developers in Arizona are being required to demonstrate adequate water supplies before selling subdivision parcels (U.S. Water News 2007, 2008a, 2008b; Sanderford 2005; Anderson 2007). The implementation of new conservation practices and significant changes to land use and human activities are both required to help ensure sustainable water resources management.

In a collaborative spirit, some groups are teaming up to meet these challenges. For example, the Great Lakes and St. Lawrence Cities Initiative is sponsoring a Water Conservation Framework aimed at reducing member communities' water use by 15% by 2015. The framework allows the dissemination and sharing of best practices among communities and represents a unified step for protecting regional water resources.

Similarly, eight of the nation's largest water agencies (i.e., Denver Water, Metropolitan Water District of Southern California, New York City Department of Environmental Protection, Portland Water Bureau, San Diego Water Authority, San Francisco Public Utilities Commission, Seattle Public Utilities, and Southern Nevada Water Authority) have formed the Water Utility Climate Alliance (Denver Water 2008). The goal of the Alliance is to work together to improve research on the effect of climate change on water utilities, develop strategies for adapting to climate change, and implement tactics to reduce their greenhouse gas emissions.

Whether sustainable water management issues are tackled by individuals, governments, or private entities, and through water planning, drought planning, or climate change planning processes, risk management should be an important component. As stated in the title of a recent article in *Science*, "stationarity is dead" (Milly et al. 2008). Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is being challenged by new understandings of climate change. In short, water managers cannot merely look to the past for statistical and management solutions. We are operating in an uncertain world and our ideas and actions must reflect its dynamic nature.

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