The Basics of Drought Planning: A 10-Step Process

Donald A. Wilhite
Michael J. Hayes
Cody Knutson
Kelly Helm Smith

Because droughts are a normal part of virtually any climate, it is important to develop plans to reduce their impacts. The drought planning process outlined here was first published in 1990, as part of a research project funded by the National Science Foundation (Wilhite, 1990). Since 1990, it has been revised and updated several times to reflect greater state, national, and international experience in drought planning. Greater emphasis on mitigation and preparedness; recent workshops on drought planning; and a methodology for conducting risk analysis have also helped reshape the drought planning methodology. The process discussed in this paper is written for application at the state level, but the methodology is generic and can be adapted to any level of government in any country.

10 Steps for Drought Planning

1. **Appoint a Drought Task Force**
2. **State the Purpose and Objectives of the Drought Plan**
3. **Seek Stakeholder Participation and Resolve Conflict**
4. **Inventory Resources and Identify Groups at Risk**
5. **Develop Organizational Structure and Prepare Drought Plan**
6. **Integrate Science and Policy, Close Institutional Gaps**
7. **Publicize the Proposed Plan, Solicit Reaction**
8. **Implement the Plan**
9. **Develop Education Programs**
10. **Post-Drought Evaluation**

Step 1: Appoint a Drought Task Force

The drought planning process is initiated through appointment of a drought task force by the governor. The task force has two purposes. First, the task force supervises and coordinates development of the plan. Second, after the plan is developed and during times of drought when the plan is activated, the task force coordinates actions, implements mitigation and response programs, and makes policy recommendations to the governor. The task force is encouraged to oversee development of a website that would contain information about the planning process, a copy of the plan, and current climate and water supply information.

The task force should reflect the multidisciplinary nature of drought and its impacts, and it should include representatives of both state and federal government agencies and universities (e.g., representatives from extension, climatologists, policy specialists, planners). A representative from the governor's office should be a member of the task force. Environmental and public interest groups and others from the private sector, including industries, can be included on the task force, and/or on sector-specific working groups of the risk assessment committee, or an advisory council, or they can be otherwise involved, as appropriate. The actual makeup of this task force would be highly variable between states, reflecting the state's political and economic character.

Depending on the nature of recent experiences with drought, the task force may find itself in the public spotlight from the outset, or it may work in relative obscurity. No matter what the initial level of public attention is, the task force needs to incorporate people who know how to conduct effective two-way communication with the public. Ideally, the task force should include or have access to a public information official who is familiar with local media's needs and

preferences and a public participation practitioner who can help establish processes that accommodate both well-funded and disadvantaged groups.

Step 2: State the Purpose and Objectives of the Drought Plan

As its first official action, the drought task force should state the general purpose for the drought plan. State officials should consider many questions as they define the purpose of the plan, such as the:

- purpose and role of state government in drought mitigation and response efforts;
- scope of the plan;
- most drought-prone areas of the state;
- historical impacts of drought;
- historical response to drought;
- most vulnerable economic and social sectors;
- role of the plan in resolving conflict between water users and other vulnerable groups during periods of shortage;
- current trends (e.g., land and water use, population growth) that may increase/decrease vulnerability and conflicts in the future;
- resources (human and economic) that the state is willing to commit to the planning process;
- legal and social implications of the plan; and
- principal environmental concerns caused by drought.

A generic statement of purpose for a plan is to reduce the impacts of drought by identifying principal activities, groups, or regions most at risk and developing mitigation actions and programs that alter these vulnerabilities. The plan is directed at providing government with an effective and systematic means of assessing drought conditions, developing mitigation actions and programs to reduce risk in advance of drought, and developing response options that minimize economic stress, environmental losses, and social hardships during drought.

The task force should then identify the specific objectives that support the purpose of the plan. Drought plan objectives will, of course, vary between states and should reflect the unique physical, environmental, socioeconomic, and political characteristics of each state. At the state level, plan objectives will place less emphasis on financial assistance measures (traditionally a role of the federal government in the United States) than would the objectives of a national plan. Technical assistance is a common element of state agency missions. Support for educational and research programs is typically a shared responsibility of state and federal government. Objectives that states should consider include the following:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of state and federal programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas of the state and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state.

Step 3: Seek Stakeholder Participation and Resolve Conflict

Social, economic, and environmental values often clash as competition for scarce water resources intensifies. Therefore, it is essential for task force members to identify all citizen groups that have a stake in drought planning (stakeholders) and their interests. These groups must be involved early and continuously in order for there to be fair representation and effective drought management and planning. Discussing concerns early in the process gives participants a chance to develop an understanding of one another's various viewpoints, and to generate collaborative solutions. Although the level of involvement of these groups will vary notably from state to state, the power of public interest groups in policy making is considerable. In fact, these groups are likely to impede progress in the development of plans if they are not included in the process. The task force should also protect the interests of stakeholders who may lack the financial resources to serve as their own advocates.

Public participation takes many forms. Time and money may constrain how actively the task force can solicit input from stakeholders. One way to facilitate public participation is to establish a citizen's advisory council as a permanent feature of the drought plan, to help the task force keep information flowing and resolve conflicts between stakeholders. Another way is to invite stakeholders to serve on working groups of the risk assessment committee.

States should also consider whether district or regional advisory councils need to be established. These councils could bring neighbors together to discuss their water use issues and problems and seek collaborative solutions. At the state level, a representative of each district council should be included in the membership of the state's citizens' advisory council to represent the interests and values of their constituencies. The state's citizens' advisory council can then make recommendations and express concerns to the task force as well as respond to requests for situation reports and updates.

Step 4: Inventory Resources and Identify Groups at Risk

An inventory of natural, biological, and human resources, including the identification of constraints that may impede the planning process, may need to be initiated by the task force. In most states in the United States, much information already exists about natural and biological resources through various state and federal agencies. It is important to determine the vulnerability of these resources to periods of water shortage that result from drought. The most obvious *natural* resource of importance is water: where is it located, how accessible is it, of what quality is it? *Biological resources* refer to the quantity and quality of grasslands/rangelands, forests, wildlife, and so forth. *Human resources* include the labor needed to develop water resources, lay pipeline, haul water and livestock feed, process citizen complaints, provide technical assistance, and direct citizens to available services.

It is also imperative to identify constraints to the planning process and to the activation of the plan in response to a developing drought. These constraints may be physical, financial, legal, or political. The costs associated with the development of a plan must be weighed against the losses that will likely result if no plan is in place. The purpose of a drought plan is to reduce risk and therefore economic, social, and environmental impacts. Generally speaking, the costs associated with the development of a state-level plan have been $50,000-$100,000, plus in-kind costs to state and federal agencies. This price tag seems inconsequential in comparison to the impacts associated with drought. Legal constraints can include water rights, existing public trust laws, requirements for public water suppliers, liability issues, and so forth.

In drought planning, making the transition from crisis to risk management is difficult because, historically, little has been done to understand and address the risks associated with drought. To solve this problem, areas of high risk should be identified, as should actions that can be taken before a drought occurs to reduce those risks. Risk is defined by both the exposure of a location to the drought hazard and the vulnerability of that location to periods of drought-induced water shortages (Blaikie et al., 1994). Drought is a natural event; it is important to define the exposure (i.e., frequency of drought of various intensities and durations) of various parts of the state to the drought hazard. Some areas are likely to be more at risk than others. Vulnerability, on the other hand, is

defined by social factors such as land use patterns, government policies, social behavior, water use, population, economic development, diversity of economic base, cultural composition, and so forth. The drought task force should address these issues early in the planning process so they can provide more direction to the committees and working groups that will be developed under Step 5 of the planning process.

Step 5: Develop Organizational Structure and Prepare Drought Plan

This step describes the process of establishing relevant committees to develop and write the drought plan and develop the necessary organizational structure to carry out its responsibilities. The drought plan should have three primary components: monitoring, risk assessment, and mitigation and response. It is recommended that committees be established to focus on the first two of these needs; the mitigation and response function can in most instances be carried out by the drought task force (Figure 1).

These committees will have their own tasks and goals, but well-established communication and information flow between committees and the task force is a necessity to ensure effective planning.

Task Force (Mitigation and Drought Response)

It is recommended that the task force (see Step 1), working in cooperation with the monitoring and risk assessment committees, have the knowledge and experience to understand drought mitigation techniques, risk analysis (economic, environmental, and social aspects), and drought-related decision-making processes at all levels of government. The drought task force, as originally defined, is composed of senior policy makers from various state and federal agencies. The group should be in an excellent position to recommend and/or implement mitigation actions, request assistance through various federal programs, or make policy recommendations to the legislature and governor.

Specific responsibilities of the task force at this point are to:

1. Determine mitigation and response actions for each of the principal impact sectors, in close cooperation with the risk assessment committee. Wilhite (1997) recently completed an assessment of drought mitigation technologies implemented by states in response to drought conditions during the late 1980s and early 1990s (http:/drought.unl.edu/mitigate/policy/mitig.htm#analysis—see overview, next page). However, the transferability of these technologies to specific situations in other states needs to be evaluated further because they may not be directly transferable in some cases. Working with the risk assessment committee, the task force should come up with recommendations addressing drought on two different time scales:

   - Short-term responses to implement during drought, such as voluntary water conservation guidelines, a ready-to-roll hay hotline, streamlined administrative procedures for evaluating emergency assistance applications, and preproduced infomercials leading agricultural producers and citizens to information on best management practices.
   - Long-term drought mitigation projects, such as education programs to give various audiences the background they need to interpret drought news reports or scientific drought indices; programs to persuade people to adopt measures that enhance organic content in soil, conserve water, and otherwise boost the resilience of natural and social systems that are vulnerable to drought.

   Assuming there is no ongoing drought, it's a good idea to publicize the recommendations of the task force and seek public input before the plan is implemented, particularly if anything seems revolutionary or controversial.
2. Inventory all forms of assistance available from local, state, and federal government during severe drought. The task force should evaluate these programs for their ability to address short-term emergencies and long-term vulnerability to drought. Assistance should be defined very broadly to include all forms of technical, mitigation, and relief programs available. Drought program inventories are available on the web: the *Catalog of Federal Assistance Programs* (http://drought.unl.edu/wdcc/products/cat99.pdf)

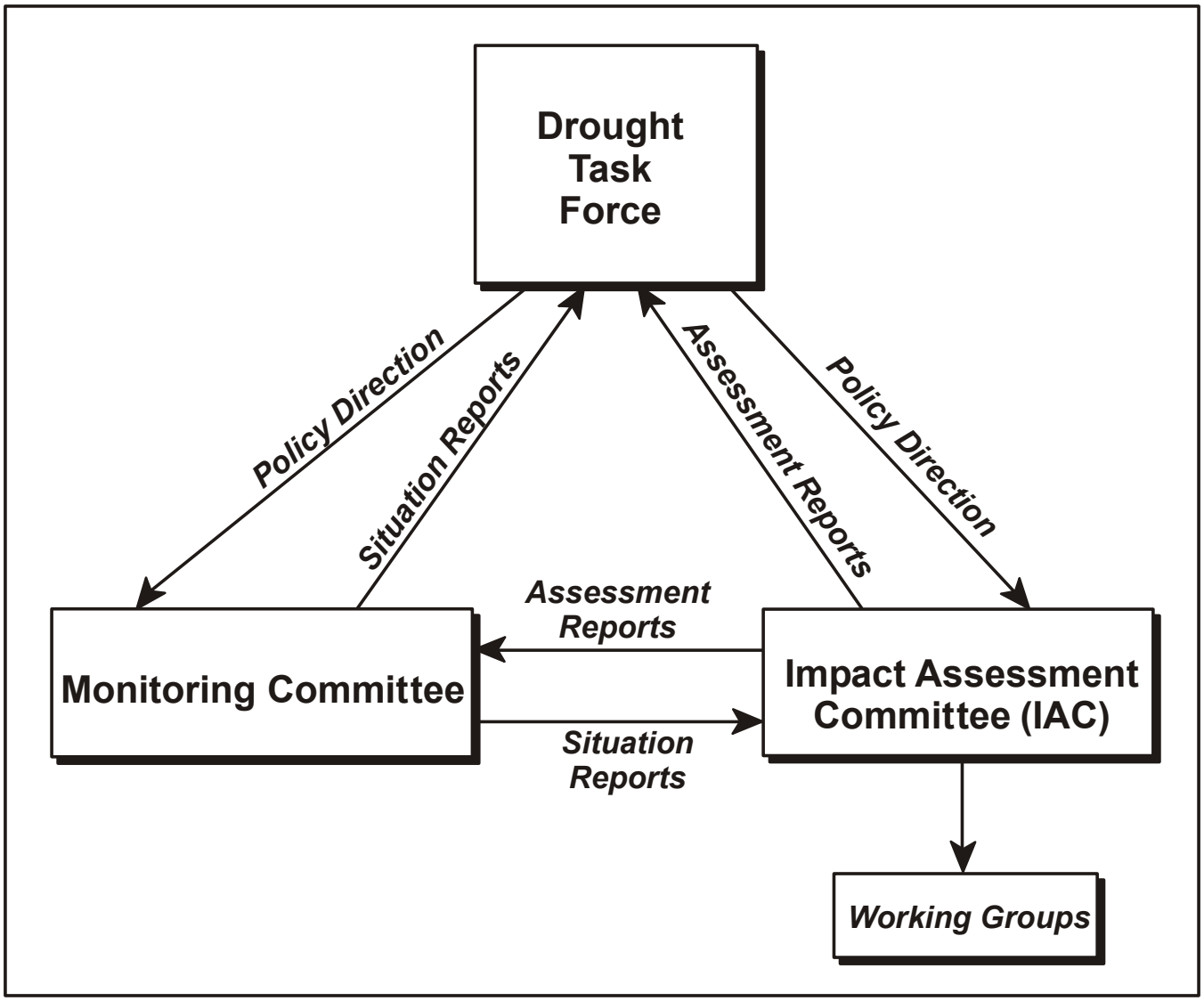

Figure 1. Linkages and suggested components of a drought plan.

Mitigation Tools

http://drought.unl.edu/mitigate/policy/mitig.htm#analysis

States have used numerous tools and strategies to deal with drought. Their varied choices reflect the complex nature of drought:

Assessment Tools Early warning systems; inventories and surveys of resources, needs, and feasible actions; data collection networks

Legislation and Public Policy Tools Legislation protecting water resources and providing loans to farmers; water plans; water banks

Increasing/Augmenting Water Supply Water recycling projects, reservoir rehabilitation, pumps and pipes to distribute water, emergency permits for water use

Public Education Drought information meetings, water conservation awareness programs and pamphlets, workshops on drought-related topics, drought information centers

Technical Assistance Advice and information to people and organizations on water quantity/quality, drought planning, water conservation; technologies and software for irrigators and water suppliers

Conservation/Demand Reduction Economic incentives for water conservation; water metering and leak detection programs

Emergency Response Water hauling programs for livestock, hay hotlines and emergency hay shipments, water system improvements/creation, emergency irrigation permits, low-interest agricultural loan and aid programs

Conflict Resolution Resolving/negotiating water use conflicts, investigating water use complaints, clarifying state water-related laws

and the National Drought Policy Commission's analysis (http://www.fsa.usda.gov/drought/finalreport/appendices.htm), although it's important to note that the NDPC listing includes programs that have never been funded.

3. Work with the monitoring and risk assessment committees to establish triggers. The monitoring committee can advise the task force on which drought and water supply indices are most relevant for the state or region. It is helpful to establish a sequence of descriptive terms for water supply alert levels, such as "advisory," "alert," "emergency," and "rationing" (as opposed to more generic terms such as "phase 1" and "phase 2," or sensational terms such as "disaster"). The task force should review the terminology used by other entities (i.e., local utilities, states, river basin commissions) and choose terms that are consistent in areas where authorities may have overlapping regional responsibilities. State authorities may wish to provide technical assistance or other forms of encouragement to help local water suppliers establish triggers for different stages of rationing before a drought. Some states, such as California, mandate that every water supplier have a drought contingency plan.
4. Establish drought management areas (i.e., subdivide the state or region into more conveniently sized districts by political boundaries, shared hydrological characteristics, climatological characteristics, or other means such as drought probability or risk). These subdivisions may be useful in drought management since they may allow drought stages and mitigation and response options to be regionalized. Climatic divisions are the most commonly used subdivisions at the state level, but they may not be the most appropriate, given topographic features, land use patterns, or water use characteristics. The task force should work closely with the monitoring committee to understand natural boundaries as well as limitations imposed by existing data collection systems, and with the risk assessment committee to understand the timing of drought's effects on different economic sectors and social groups.
5. The drought task force should develop a website for disseminating drought monitoring information and for letting the public know about the drought plan. Models that could be followed are web pages for the states of Texas, Montana, Pennsylvania, Oklahoma, New Mexico, South Carolina, and Nebraska (http://drought.unl.edu/go/go.htm and http://drought.unl.edu/mitigate/policy/states/statedox.htm).

Monitoring Committee

A reliable assessment of water availability and its outlook for the near- and long-term is valuable information in both dry and wet periods. During drought, the

value of this information increases markedly. The monitoring committee should include representatives from agencies with responsibilities for monitoring climate and water supply. It is recommended that data and information on each of the applicable indicators (e.g., precipitation, temperature, evapotranspiration, long-range weather forecasts, soil moisture, streamflow, ground water levels, reservoir and lake levels, and snowpack) be considered in the committee's evaluation of the water situation and outlook for the state. The agencies responsible for collecting, analyzing, and disseminating data and information will vary according to the state organizational structure and by geographic region.

The monitoring committee should meet regularly, especially in advance of the peak demand season. Following each meeting, reports should be prepared and disseminated to the state's drought task force, relevant state and federal agencies, and the media. The chairperson of the monitoring committee should be a permanent member of the drought task force. In many states, this person may be the state climatologist. If conditions warrant, the task force should brief the governor about the contents of the report, including any recommendations for specific actions. It is essential for the public to receive a balanced interpretation of changing conditions. The monitoring committee should work closely with public information specialists to keep the public well informed.

The primary objectives of the monitoring committee are to:

1. Help policy makers adopt a workable definition of drought that could be used to phase in and phase out levels of state and federal actions in response to drought. It may be necessary to adopt more than one definition of drought in identifying impacts in various economic, social, and environmental sectors. Several indices are available (Hayes, 1998), including the Standardized Precipitation Index (McKee et al., 1993; 1995), which is gaining widespread acceptance (Guttman, 1998; Hayes et al., 1999; also refer to http://drought.unl.edu/watch/watch.htm#section1a—see overview on next page). The commonly used Palmer Drought Severity Index (Palmer, 1965) is being replaced or supplemented as a monitoring tool in many states. The trend is for states to rely on multiple drought indices as indicators of impacts in various sectors. The current thought is that no single index of drought is adequate to measure the complex interrelationships between the various components of the hydrological cycle and impacts.
2. Help the task force establish drought management areas (i.e., subdivide the state or region into more conveniently sized districts by political boundaries, shared hydrological characteristics, climatological characteristics, or other means such as drought probability or risk). The monitoring committee's advice may be particularly helpful in communicating natural watershed boundaries as well as the limits and constraints imposed by existing data.
3. Develop a drought monitoring system. Most states already have a good data collection system for monitoring climate and water supplies and identifying potential shortfalls. Responsibility for collecting, analyzing, and disseminating the data is divided between many state and federal agencies and other entities. The monitoring committee's challenge is to coordinate and integrate the analysis so decision makers and the public receive early warning of emerging drought conditions. On a national basis, much of this information has been compiled under the Drought Watch section of the NDMC's website (http://drought.unl.edu/ndmc/index.html). Two new products, the Drought Monitor (http://drought.unl.edu/ndmc/dm—see overview, next page) and Current Droughts Affecting the U.S. (http://drought.unl.edu/impacts/us/usimpact.htm—see overview, p. 9), are good examples. This section is also linked to specific state websites that illustrate how others are organizing information on drought conditions.

   Many states (e.g., Nebraska, Oklahoma, California) have developed automated weather data networks that provide rapid access to climate data. These networks can be invaluable in monitoring emerging and ongoing drought conditions. Data from them can be coupled with data available from federal agencies (e.g., Natural Resources Conservation Service) to provide a com-

Drought Indices

http://drought.unl.edu/watch/watch.htm#section1a

Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow, and other water supply indicators. Most water supply planners find it useful to consult one or more of these indices before making decisions. The major drought indices used in the United States and Australia are described below.

Percent of Normal This involves a simple calculation and is suited to the needs of general audiences. It is effective for analyses involving a single region or season.

Standardized Precipitation Index The SPI is based on the probability of precipitation for any time period. It can be computed for different time scales, and it can provide early warning of drought and help assess drought severity.

Palmer Drought Severity Index The Palmer, the first comprehensive drought index developed in the United States, is a soil moisture algorithm calibrated for relatively homogeneous regions. Palmer values may lag emerging droughts by several months, and it is not well suited to mountainous land or areas of climatic extremes. Many U.S. government agencies and states use the PDSI to trigger programs.

Surface Water Supply Index The SWSI was designed to complement the Palmer in Colorado, where mountain snowpack is a key element of water supply. It is calculated by river basin based on snowpack, streamflow, precipitation, and reservoir storage.

Reclamation Drought Index This index is also calculated at the river basin level. It incorporates temperature, precipitation, snowpack, streamflow, and reservoir levels.

Deciles Monthly precipitation occurrences are grouped into deciles, so that, by definition, "much lower than normal" weather cannot occur more than 20% of the time. It is used in Australia.

prehensive monitoring of climate and water systems. Data and data products should be disseminated on a timely basis in printed form and electronically via the World Wide Web.

4. Inventory data quantity and quality from current observation networks. Many networks monitor key elements of the hydrologic system. Most of these networks are operated by federal or state agencies, but other networks also exist and may provide critical information for a portion of a state or region. Meteorological data are important but represent only one part of a comprehensive monitoring system. Other physical indicators (soil moisture, streamflow, reservoir and ground water levels) must be monitored to reflect impacts of drought on agriculture, households, industry, energy production, and other water users. Helpful

The Drought Monitor

http://drought.unl.edu/ndmc/dm/

The Drought Monitor map summarizes information from numerous drought indices and indicators to provide a weekly overview of drought in the United States—where it is emerging, lingering, subsiding, or forecast. It is the product of a three-way partnership of the National Drought Mitigation Center at the University of Nebraska–Lincoln, the U.S. Department of Agriculture, and the National Weather Service's Climate Prediction Center. Among the indices and indicators incorporated in the map:

- Palmer Drought Severity Index
- Crop Moisture Index
- Standardized Precipitation Index
- "Drought Impacts in the U.S." report
- Percent of normal rainfall
- Daily streamflow
- Snowpack
- Soil moisture
- Daily soil moisture anomaly
- Vegetation and Temperature Condition Index
- Climate outlooks
- Streamflow forecasts
- Forecast Palmer Drought Severity Index
- Soil moisture forecasts

This information is "blended" into a map that uses a classification system to show drought intensity and type, similar to the schemes in use for hurricanes and tornadoes. The categories (D0—Abnormally Dry; D1—Drought–Moderate; D2—Drought–Severe; D3—Drought–Extreme; D4—Drought–Exceptional) are based on various indicators. Because the ranges of these indicators often don't coincide, the final drought category tends to be based on the majority of the indicators. The analysts producing the map also weight the indices according to how well they perform in various parts of the country and at different times of the year. The final maps are tweaked to reflect real-world conditions as reported by experts throughout the country.

Drought Impacts in the US

http://drought.unl.edu/impacts/us/usimpact.htm

"Drought Impacts in the US" is a monthly report produced by the National Drought Mitigation Center as a complement to the Drought Monitor map. The report contains a map outlining drought recovery areas in the United States. It also provides state-by-state details of drought impacts and information on how states are preparing for and responding to drought.

technology includes soil moisture sensors, automated weather stations, and satellite data such as digital data obtained from the Advanced Very High Resolution Radiometer (AVHRR), transmitted from a National Oceanic and Atmospheric Administration satellite, which is useful in detecting areas where moisture deficiencies are affecting vegetation growth. Much of this data will be integrated under the Unified Climate Access Network (UCAN).

5. Work closely with the task force and risk assessment committees to determine the data needs of primary users. Developing new or modifying existing data collection systems is most effective when the people who will be using the data are consulted early and often. Soliciting input on expected new products or obtaining feedback on existing products is critical to ensuring that products meet the needs of primary users and will be used in decision making. Training on how to use or apply products in routine decision making is also essential.
6. Develop and/or modify current data and information delivery systems. People need to be warned of drought as soon as it is detected, but often they are not. Information needs to reach people in time for them to use it in making decisions. In establishing information channels, the monitoring committee needs to consider when people need various kinds of information. These decision points can determine whether the information provided is used or ignored.

Risk Assessment Committee

Drought impacts cut across many sectors and across normal divisions of responsibility of local, state, and federal agencies. These impacts have been classified by Wilhite and Vanyarkho (2000) and are chronicled in the "Impacts" section of the NDMC's website (http://drought.unl.edu/impacts/effects.htm—see overview, next page). Risk is the result of exposure to the drought hazard (i.e., probability of occurrence) and societal vulnerability, represented by a combination of economic, environmental, and social factors. Therefore, to reduce vulnerability to drought, it is essential to identify the most significant impacts and assess their underlying causes.

The membership of the risk assessment committee should represent economic sectors, social groups, and ecosystems most at risk from drought. The committee's chairperson should be a member of the task force.

The most effective approach to follow in determining vulnerability to and impacts of drought is to create working groups under the aegis of the risk assessment committee. The responsibility of the committee and working groups is to assess sectors, population groups, and ecosystems most at risk and identify appropriate and reasonable mitigation measures to address these risks. Working groups would be composed of technical specialists and stakeholders representing those areas referred to above. The chair of each working group, as a member of the risk assessment committee, would report directly to the committee. Following this model, the responsibility of the committee is to direct the activities of each of the working groups and make recommendations to the drought task force on mitigation actions.

The number of working groups will vary considerably between states. Colorado has identified eight impact working groups: municipal water, wildfire protection, agricultural industry, commerce and tourism, wildlife, economic, energy loss, and health. Idaho's drought plan outlines the responsibilities of five subcommittees: water data, public information, agriculture, municipal supplies and water quality, and recreation and tourism. New Mexico uses four sub-groups: agricultural; drinking water, health, and energy; wildlife and wildfire protection; and tourism and economic

Types of Impacts

http://drought.unl.edu/impacts/effects.htm

Droughts can have wide-ranging, complex impacts. These impacts are commonly referred to as direct or primary (such as reduced crop productivity or increased fire hazard) or indirect or secondary (such as reduced income for farmers). They can be economic, environmental, or social:

Economic impacts include costs to and losses in agricultural, livestock, timber, and fishery production; general economic effects, such as decreased land prices and rural population loss; losses to the recreation and tourism industries; energy-related effects; losses to water suppliers; losses in the transportation industry; and increased food prices due to declining food production.

Environmental impacts include damage to animal species; hydrological effects, such as lower water levels in reservoirs, lakes, and ponds; damage to plant communities; increased number and severity of fires; and increased dust and pollutants.

Social impacts include adverse effects on health, including mental and physical stress; increased conflicts over water; reduced quality of life; disruption of cultural belief systems and re-evaluation of social values; and institutional restraints on water use.

impact. Nebraska's drought plan identifies two working groups: agriculture, natural resources, wildlife, tourism, and recreation; and municipal water supply, health, and energy.

A methodology for assessing and reducing the risks associated with drought has recently been completed as a result of collaboration between the NDMC and the Western Drought Coordination Council's (WDCC) Mitigation and Response Working Group (Knutson et al., 1998) and is available on the NDMC's website at http://drought.unl.edu/handbook/risk.pdf. The guide focuses on identifying and assigning priorities to drought impacts, determining their underlying causes, and choosing actions to address the underlying causes. This methodology can be employed by each of the working groups. This effort requires an interdisciplinary analysis of impacts and management options and is divided into six tasks:

1. **Assemble the team.** Select stakeholders, government planners, and others with a working knowledge of drought's effects on primary sectors, regions, and people.
2. **Evaluate the effects of past droughts.** Identify how drought has affected the region, group, or ecosystem. Consult climatological records to determine the "drought of record," the worst in recorded history, and project what would happen if a similar drought occurred this year or in the near future, considering changes in land use, population growth, and development that have taken place since that drought.
3. **Rank impacts.** Determine which drought effects are most urgently in need of attention. Various considerations in assigning priority to these effects include cost, areal extent, trends over time, public opinion, social equity, and the ability of the affected area to recover.
4. **Identify underlying causes.** Determine those factors that are causing the highest levels of risk for various sectors, regions, and populations. For example, an unreliable source of water for municipalities in a particular region may explain the impacts that have resulted from recent droughts in that area. To reduce the potential for drought impacts in the future, it is necessary to understand the underlying environmental, economic, and social causes of these impacts. To do this, drought impacts must be identified and the reason for their occurrence determined.
5. **Identify ways to reduce risk.** Identify actions that can be taken before drought that will reduce risk. In the example above, taking steps to identify new or alternative sources of water (e.g., ground water) could increase resiliency to subsequent episodes of drought.
6. **Write a "to do" list.** Work with the task force to assign priority to options according to what is likely to be the most feasible, cost-effective, and socially equitable. Implement steps to address these actions through existing government programs or the legislative process.

This process has the potential to lead to the identification of effective and appropriate drought risk reduction activities that will reduce long-term drought impacts, rather than ad hoc responses or untested mitigation actions that may not effectively reduce the impact of future droughts.

Step 6: Integrate Science and Policy, Close Institutional Gaps

An essential aspect of the planning process is integrating the science and policy of drought management. The policy maker's understanding of the scientific issues and technical constraints involved in addressing problems associated with drought is often limited. Likewise, scientists generally have a poor understanding of existing policy constraints for responding to the impacts of drought. In many cases, communication and understanding between the science and policy communities must be enhanced if the planning process is to be successful. Integration of science and policy during the planning process will also be useful in setting research priorities and synthesizing current understanding. The drought task force should consider various alternatives to bring these groups together and maintain a strong working relationship.

As research needs and gaps in institutional responsibility become apparent during drought planning, the drought task force should compile a list of those deficiencies and make recommendations on how to remedy them to the governor, relevant state agencies, and the legislature. For example, the monitoring committee may recommend establishing or enhancing a ground water monitoring program. Another recommendation may be to initiate research on the development of a climate or water supply index to help monitor water supplies and trigger specific actions by state government.

Step 7: Publicize the Proposed Plan, Solicit Reaction

If there has been good communication with the public throughout the process of establishing a drought plan, there may already be better-than-normal awareness of drought and drought planning by the time the task force recommends various drought mitigation and response options. Themes to emphasize in writing news releases and organizing informational meetings during and after the drought planning process could include:

- How the drought plan is expected to relieve impacts of drought. Stories can focus on the human dimensions of drought, such as how it affects a farm family; on its environmental consequences, such as reduced wildlife habitat; and on its economic effects, such as the costs to a particular industry or to the state's overall economy.
- What it will cost to implement each option, and how it will be funded.
- What changes people might be asked to make in response to different degrees of drought, such as restricted lawn watering and car washing, or not irrigating certain crops at certain times.

In subsequent years, it may be useful to do "drought plan refresher" news releases at the beginning of the most drought-sensitive season, letting people know whether there is pressure on water supplies or reason to believe that there will be shortfalls later in the season, and reminding them of the plan's existence and history and any associated success stories. It may be useful to refresh people's memories ahead of time on circumstances that would lead to water use restrictions.

During drought, the task force should work with public information professionals to keep the public well informed of the current status of water supplies, whether conditions are approaching "trigger points" that will lead to requests for voluntary or mandatory use restrictions, and how victims of drought can access assistance. All pertinent information should also be available on the state's drought website so that the public can get information directly from the task force without having to rely on mass media.

Step 8: Implement the Plan

Once the task force and any external constituencies have agreed on the plan, the task force and/or its designated representatives should oversee implementation of both the short-term operational aspects of the plan and long-term mitigation measures. Periodic testing, evaluation, and updating of the drought plan will help keep the plan responsive to state needs. An on-

going or operational evaluation keeps track of how societal changes such as new technology, new research, new laws, and changes in political leadership may affect drought risk and the operational aspects of the drought plan. Drought risk may be evaluated quite frequently while the overall drought plan may be evaluated less often. An evaluation under simulated drought conditions (i.e., drought exercise) is recommended before the drought plan is implemented and periodically thereafter. The virtual drought exercise developed in association with a recent national study conducted by the U.S. Army Corps of Engineers (Werick and Whipple, 1994) is one mechanism that has been used to simulate drought conditions and related decisions. It is important to remember that drought planning is a process, not a discrete event.

Long-term mitigation measures, such as implementing policies that require conjunctive use of ground and surface water, may require drafting new legislation and finding funds to support new monitoring and regulation efforts. In any case, it is essential to recognize that reducing long-term vulnerability to drought will require a sustained effort, although it may be a matter of long-term programs undertaken by a variety of agencies.

Step 9: Develop Education Programs

A broad-based education program to raise awareness of short- and long-term water supply issues will help ensure that people know how to respond to drought when it occurs and that drought planning does not lose ground during nondrought years. It would be useful to tailor information to the needs of specific groups (e.g., elementary and secondary education, small business, industry, homeowners, utilities). The drought task force or participating agencies should consider developing presentations and educational materials for events such as a water awareness week, community observations of Earth Day, relevant trade shows, specialized workshops, and other gatherings that focus on natural resource stewardship or management.

Step 10: Post-Drought Evaluation

A post-drought evaluation or audit documents and analyzes the assessment and response actions of government, nongovernmental organizations, and others, and provides for a mechanism to implement recommendations for improving the system. Without post-drought evaluations, it is difficult to learn from past successes and mistakes, because institutional memory fades.

Post-drought evaluations should include an analysis of the climatic and environmental aspects of the drought; its economic and social consequences; the extent to which pre-drought planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in post-recovery; and any other weaknesses or problems caused or not covered by the plan. Attention must also be directed to situations in which drought-coping mechanisms worked and where societies exhibited resilience; evaluations should not focus only on those situations in which coping mechanisms failed. Evaluations of previous responses to severe drought are also a good planning aid.

To ensure an unbiased appraisal, governments may wish to place the responsibility for evaluating drought and societal response to it in the hands of nongovernmental organizations such as universities and/or specialized research institutes.

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Other Web Links

State and/or university websites dealing with drought:

Alabama:	www.aces.edu/drought/
Delaware:	www.dnrec.state.de.us/DNREC2000/drought.asp
Florida:	www.dca.state.fl.us/bpr/EMTOOLS/florida_drought_center.htm
Georgia:	interests.caes.uga.edu/drought/
Illinois:	www.sws.uiuc.edu/atmos/statecli/drought.htm
Indiana:	www.agriculture.purdue.edu/droughtwatch/index.html
Iowa:	www.extension.iastate.edu/Pages/communications/drought/
Kansas:	www.kwo.org/Reports/drought.htm
Kentucky:	water.nr.state.ky.us/wsp/wsp10.htm
	wwwagwx.ca.uky.edu/drought.html
Maryland:	www.mde.state.md.us/drought/default.asp
Minnesota:	www.climate.umn.edu/doc/drought_2000.htm
Missouri:	www.dnr.state.mo.us/geology/droughtupdate.htm
Montana:	www.nris.state.mt.us/Drought
Nebraska:	linux1.nrc.state.ne.us/carcunl/
New Jersey:	www.state.nj.us/drbc/Dcenter1.htm
New Mexico:	weather.nmsu.edu/drought/index.htm
North Carolina:	www.ces.ncsu.edu/drought/
	www.dwr.ehnr.state.nc.us/Water_Supply_Planning/Drought_Monitoring_Council/
North Dakota:	www.ag.ndsu.nodak.edu/drought/drought.htm
Oklahoma:	www.state.ok.us/~governor/drought.htm
	www.state.ok.us/~owrb/features/drought.html
Pennsylvania:	www.cas.psu.edu/docs/coext/disaster/disaster.html
	www.dep.state.pa.us/dep/subject/hotopics/drought/
South Carolina:	water.dnr.state.sc.us/climate/sco/drought.html
Texas:	agnews.tamu.edu/drought
	www.txwin.net/dpc/index.htm
	www.twdb.state.tx.us/DATA/DROUGHT/drought_toc.htm
Wisconsin:	www.uwex.edu/ces/news/info/drought.pdf
Wyoming:	www.uwyo.edu/ces/drought/Drought_Main.html

A number of universities, states, and federal agencies maintain automated weather data networks.
Websites of state networks:

Alabama:	www.awis.com/mesonet/index.html (Auburn University Mesonet stations)
Arizona:	ag.arizona.edu/azmet/ (AZMET, the Arizona Meteorological Network)
California:	www.cimis.water.ca.gov/ (California Irrigation Management Information System—CIMIS)
Colorado:	ccc.atmos.colostate.edu/~coagmet (CoAgMet weather stations)
Florida:	fawn.ifas.ufl.edu/ (Florida Automated Weather Network—FAWN)
Georgia:	www.griffin.peachnet.edu/bae/ (Georgia Automated Environmental Monitoring Network)
Illinois:	www.sws.uiuc.edu/warm/datalist.asp (Illinois Climate Network Data)
Iowa:	mesonet.agron.iastate.edu/agclimate/index.php (Iowa Ag Climate Network)
Indiana:	shadow.agry.purdue.edu/sc.zen-geog.html (Purdue Automated Agricultural Weather Stations Network—PAAWS)
Louisiana:	typhoon.bae.lsu.edu (Louisiana Agriclimatic Information System—LAIS)
Michigan:	www.agweather.geo.msu.edu/index.html (Michigan State University automated weather stations)
Missouri:	agebb.missouri.edu/weather/stations/index.htm (Commercial Agriculture Program weather stations)
New Mexico:	weather.nmsu.edu/stations (New Mexico State University climate stations)

North Carolina:	www.nc-climate.ncsu.edu/sco/fr_index.html?/agnet/ (NCARS Weather and Climate Network)
North Dakota:	www.ext.nodak.edu/weather/ndawn/old-ndawn-home.html (North Dakota Agricultural Weather Network—NDAWN)
Oklahoma:	okmesonet.ocs.ou.edu/ (Oklahoma Mesonet)
South Dakota:	abe.sdstate.edu/weather/weather.htm (South Dakota Automatic Weather Data Network—SD-AWDN)
Washington:	frost.prosser.wsu.edu/ (Washington State University Public Agricultural Weather System—PAWS)
Wisconsin:	www.soils.wisc.edu/wimnext/awon/awon.html (University of Wisconsin Automated Weather Observation Network—AWON)

Websites of regional networks:

Western United States:	www.met.utah.edu/jhorel/html/mesonet/ (MesoWest)
Northeastern United States:	www.erh.noaa.gov/er/btv/html/mesonethome.html (BTV Mesonet)
Pacific Northwest:	mac1.pn.usbr.gov/agrimet/ (Bureau of Reclamation's AgriMet)
U.S. High Plains:	www.hprcc.unl.edu/awdn/home.html (High Plains Climate Center's Automated Weather Data Network—AWDN)

Unified Climate Access Network (UCAN):

met-www.cit.cornell.edu/ucan.net/UCAN.html