Illinois State Water Survey
Department of Energy and Natural Resources

DROUGHT

by Steven D. Hilberg and
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Reservoir Critically Low

Coulterville Officials Declare Water Emergency

Dry soil periling Illinois crops

Chicago Tribune, Monday, January 26, 1981

Carlinville Lake continues at dangerously low water level

Experts offer strategies for coping with drought

Marion city reserv... drops; council eyes ...

Above-Normal Rainfall Pre...

Moisture Levels Remain Low

Drought widens land price range

URBANA (AP) - The range of prices for Illinois farmland has widened in the last year, with the lowest values in areas hardest hit by the heat and drought of 1980, a University of Illinois specialist says.

'Illinois' arid 'Little Egypt' thirsty for rain and snow

Farm, urban residents feel effects of drought

Centralia Water ...

Cedar Lake: A beach ...

Thursday, Jan. 29, 1981

Hauling ...

drought *or* **drouth** \'draú|th, |t, *or* + V |d•; *sometimes* -ró|\ *n* -S [ME *drougth, drought, drouth,* fr. OE *drūgath, drūgoth,* fr. *drūgian* to dry up, wither, fr. the root of *drȳge* dry — more at DRY] **1** *archaic* **:** the condition or quality of being dry **:** DRYNESS **:** lack of moisture ⟨the ~ of the sun-baked ground⟩ ⟨crickets sing at the oven's mouth . . . the blither for their ~ —Shak.⟩ **2 :** a period of dryness esp. protracted and causing extensive damage to crops or preventing their successful

A Complex Definition

In simple terms, drought is caused by too little precipitation over an extended period, often accompanied by high temperatures. For the atmospheric scientist, drought is defined as a period when precipitation is significantly less than normal over several months or more. However, the declaration of drought is made not only on the basis of meteorological or climatological values.

Even though precipitation may be deficient over a period of time, the true incidence of a drought is not evident until water supplies or other parts of the environment experience stress from the water deficiency. Different areas of Illinois vary in their susceptibility to effects from water deficiencies. Some soils withstand dry weather better than others, and some areas are more dependent than others on surface water sources (lakes and rivers) which are more susceptible to drought than groundwater sources.

The "socioeconomic" aspect of drought for a particular area often changes with time as new water supplies are developed or other means, such as new water conservation measures, are used to delay or mitigate the effects of a rainfall deficiency. Further, what is a drought for farmers may not be one for urban residents. For example, hot dry weather in July and August, a critical part of the growing season, may seriously impact agricultural productivity, but have little effect on water supplies in communities in the same area. The opposite may also be true; winter drought may seriously affect communities with marginal water supplies and have little effect on Illinois agriculture.

When does a drought begin? It is often difficult to detect since the effects of a growing precipitation deficiency appear slowly. There may be signs a drought is under way, but often little attention is given to it until the effects become very serious.

The History of Droughts in Illinois

Droughts were relatively frequent events in Illinois from 1909 through 1941. The worst Illinois droughts on record occurred in this period, mostly during the Dust Bowl years in the early 1930's. The bar graph shows the distribution and relative severity of 12-month droughts from 1905 through 1983.

There was little drought activity in the state for about 10 years from the early 1940's to the early 1950's. Then two severe droughts struck in 1953–1956. Since then there have been only three other droughts, and none of major statewide significance. A minor drought occurred in central Illinois in the early 1960's; moderate droughts occurred in south-central Illinois in 1976–1977 and again in 1980–1981.

The 30 years since Illinois experienced a truly severe drought has been a period of rapidly changing agricultural technology, major new

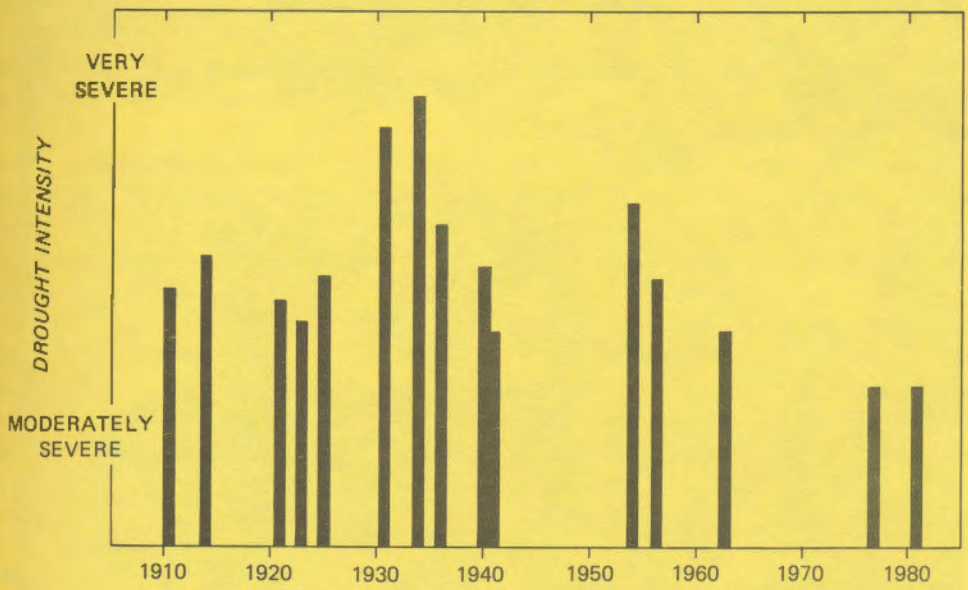


FIGURE 1. This bar graph shows the relative severity of 12-month droughts between 1905 and 1983. Droughts have been infrequent and only moderately severe since the early 1950's.

water resource development, and a major shift in life styles and accordingly in water use. When more severe droughts occur again, their impact will greatly affect the state and in ways not previously experienced.

What Causes Drought?

The Climate Factors

To understand how weather factors influence drought, one needs to consider important aspects of the Illinois climate. The average annual precipitation in Illinois ranges from around 33 inches in extreme northern Illinois to over 46 inches in the extreme south. The winter months typically have less precipitation than other months, and April, May and June are the wettest months. Although average precipitation is much higher in southern Illinois, it is also more variable from year to year than elsewhere in the state. In the past, droughts have been more severe where this interannual variability is the greatest.

The yearly variability of rainfall in the Midwest is largely a result of the distribution of thunderstorms. Areas with a high frequency of thunderstorms have more rain and yet more variability in their annual rainfall. A dry period in Illinois often has a near normal number of days with measurable rain, but when it rains, the rains are often more spotty and less intense than in wetter periods.

Temperature also plays a role in drought severity. Droughts tend to be more severe where temperatures are higher and cause more evapotranspiration. (Evapotranspiration is the com-

A dry period in Illinois often has a near normal number of days with rain, but rains are more spotty and less intense

High pressure systems persisting over the Midwest may initiate drought. Fair weather cumulus clouds may form, but the stable air associated with the high pressure system will inhibit the further development of these clouds into showers and thunderstorms.

bination of evaporation from the soil and transpiration from plants.) The latitudinal temperature variation in Illinois (higher temperatures in the south) coupled with large variations in precipitation from year to year make southern Illinois the most drought-prone area of the state.

The Weather Factors

Several atmospheric conditions help cause a drought. Wind patterns four to five miles high affect the speed and orientation of rain-bearing frontal systems passing through Illinois, as well as the flow of moisture into the Midwest. Dry weather is most likely in the cool season when winds in the upper atmosphere over the Midwest blow from the northwest to southeast. If this pattern persists, dryness can develop.

During the warm season, fronts trigger most showers and thunderstorms. Drought can be initiated when a large warm high pressure system settles in over the lower Midwest. Storm systems and fronts which normally might bring showers and thunderstorms are either deflected to the north or are weakened considerably by the high pressure system. In addition, the high pressure can prevent the flow of moisture from the Gulf of Mexico into Illinois. Even when frontal systems pass through Illinois, there may not be enough moisture available for heavy widespread rain to develop.

The Environmental Factors

The deficiencies in precipitation and higher than normal temperatures which bring on drought conditions are first seen in other parts of the hydrological cycle. Initially, less surface runoff occurs and less water percolates into the ground. The first major environmental effects

evident, then, are lower soil moisture and reduced streamflows. Relatively higher temperatures lead to more evaporation. Less water flows to urban and recreational reservoirs and farm ponds.

The decreased soil moisture means less water into shallow groundwater aquifers that supply many wells, which in turn reduces the groundwater recharge to streams. It also leads to poorer plant growth, affecting crops, gardens, and other plant life. Drier conditions lead to increased numbers of certain insects and to more wind erosion.

The natural habitat of Illinois has developed by experiencing and adjusting to climate extremes, including droughts. As a result it is not seriously impacted by drought except in circumstances where human changes in land use have put certain species and habitats under great stress during drought.

The Human Factors

Many times a drought is aggravated by human activities, or lack of them. A drought for a municipality occurs with a public water supply shortage. This results from reduced streamflow to a reservoir, but the "drought" will appear sooner if the reservoir has become heavily silted, or if usage of water has increased with time. What may be a drought for one city or village may not be for another if their supply lakes are different in size or condition. Inadequate maintenance of reservoirs, leaky distribution systems, waste of water, and lack of adjustment to population and industrial growth are some of the things that can make a municipality more susceptible to drought.

Drought is sometimes aggravated by human activities, or lack of them.

What Makes a Dry Period a Drought?

Drought is a period when precipitation is significantly below normal. Percentage of normal precipitation is often used to define drought severity, since this allows a comparison of both relative and absolute magnitudes of precipitation deficiency.

Frequencies of droughts of various lengths and their severity across the state are important considerations in the design of water structures. Figure 2 shows the intensity of 3-month droughts expected to recur at least once every 2 years and once every 10 years. For example, in southwestern Illinois we can expect less than 32% of normal precipitation to occur at least once every 10 years. The departures expected in northwestern Illinois are not as extreme – 40% of normal. Similarly, a 3-month drought that can be expected to occur at least once every 2 years would have precipitation ranging from 48% of normal in southwestern Illinois to 64% of normal in northwestern Illinois.

The probability of 3-month precipitation droughts is greatest in Illinois during the winter months (December-February), although the probability for winter drought decreases from north to south. When these droughts occur they tend to cover more area in northern Illinois than in southern Illinois, but those in southern Illinois tend to be more severe (greater deficiencies).

Droughts lasting a year or longer tend to begin in summer, and the period of relative greatest precipitation deficiency typically occurs in the winter season. They are usually most severe in southern Illinois with the area of greatest deficiency oriented from west to east. In 1 year and longer droughts, 70% to 80% of the months have below normal precipitation with normal or above in the other months. Severe droughts lasting more than 24 months are infrequent in Illinois. In fact, there has not been a drought of this duration since the early 1950's.

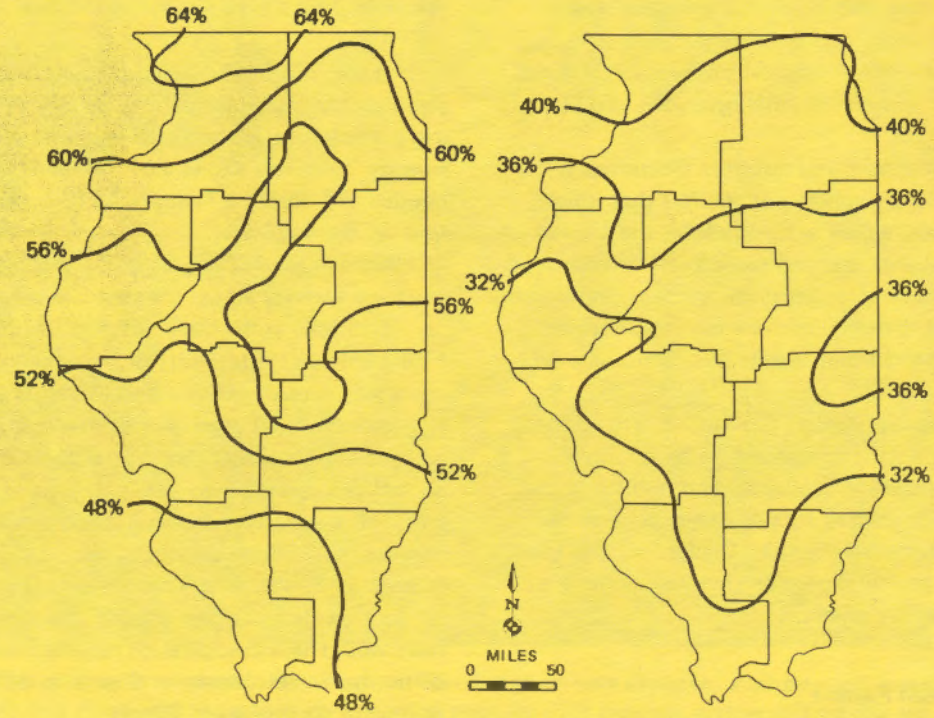


FIGURE 2. These maps show the intensity of 3-month droughts expected to occur once every 2 years (a) and once every 10 years (b) expressed as percent of normal precipitation. For example, precipitation during a 3-month drought may be as low as 48% of normal about once every 2 years in southern Illinois. Precipitation this low would occur about once every 5-10 years in northern Illinois.

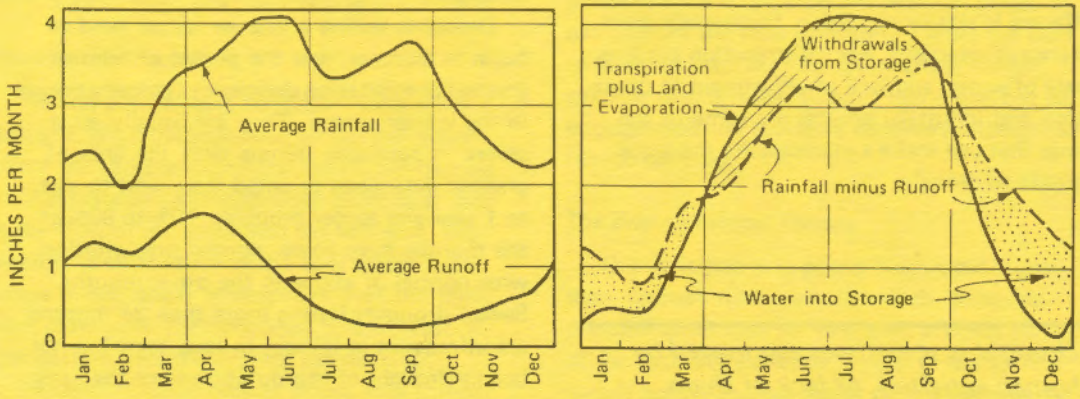
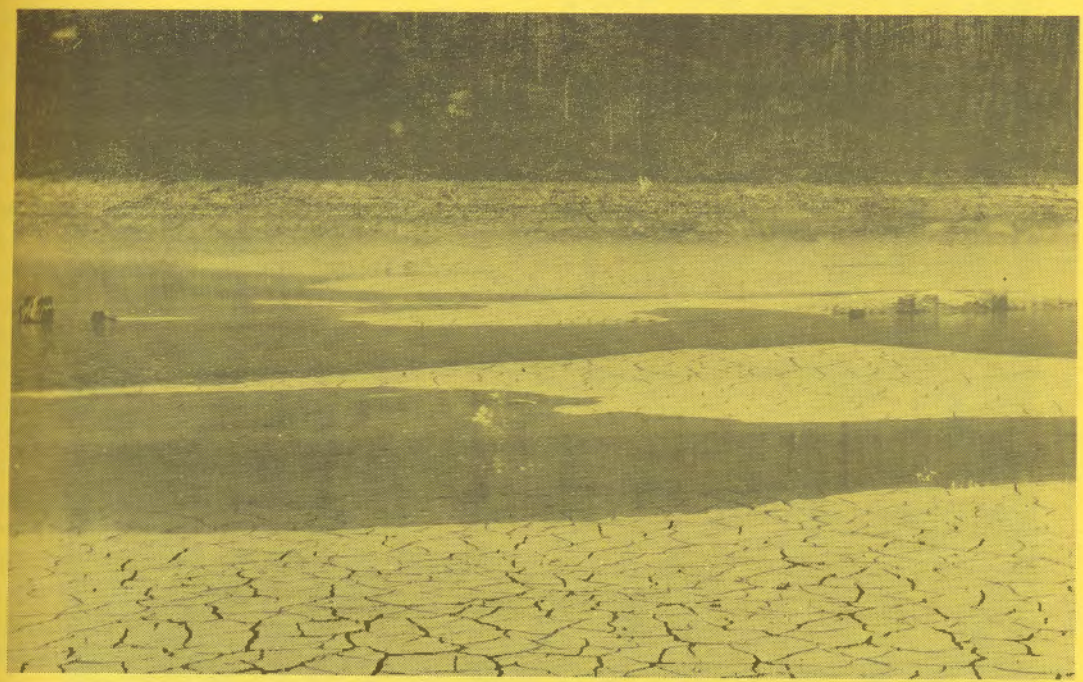


FIGURE 3. This is a depiction of the seasonal variations in the hydrologic cycle for southern Illinois

Streams and Rivers

Streamflow normally varies seasonally reflecting normal variations in precipitation, evapotranspiration, and the storage of groundwater and soil moisture. The seasonal variation in the hydrologic cycle for southern Illinois (figure 3) illustrates that in the warm season (April-September), when transpiration from plants and evaporation from surface water is high, groundwater and soil moisture levels are reduced. During the cold season (October-March), when evapotranspiration is low, soil moisture usually builds up to nearly saturated levels. By February and March, when soil moisture is usually very high, about 60% of all precipitation becomes runoff. In August and September, when evapotranspiration is high and soil moisture needs to be replenished due to growing crops, streamflow volume is normally less than 10% of rainfall volume. This is why many droughts, as measured by streamflow, begin in the warm season.

These relationships between precipitation, water storage, evapotranspiration, and streamflow change markedly during a drought. In the early months of a drought, runoff becomes less and soil moisture is depleted because rainfall is below normal. As the soil moisture to supply plants and shallow groundwater decreases, a higher percentage of whatever precipitation occurs goes toward replenishing the soil moisture and thus a lesser amount goes to runoff and streamflow. The effect on streams is more serious in southern Illinois than in the northern part of the state, especially in the early stages of drought. In northern Illinois a larger percent-



Sediment accumulation in lakes and reservoirs decreases storage capacity. Communities depending on these sources for their water supplies are more likely to experience water shortages during extended drought.

Urban water shortages during drought are most likely in southern Illinois. Droughts are typically more severe there and most public water supplies are surface impoundments.

age of streamflow comes from groundwater discharge into streams, whereas in southern Illinois this percentage is very small largely because of soil differences. Streamflow during droughts in southern Illinois averages less than 10% of the normal flow.

Lakes and Reservoirs

Most lakes and reservoirs used for public water supplies are fed by streams. Large reservoirs supplied by major streams are able to withstand most Illinois droughts. However, smaller reservoirs and farm ponds used as water supplies are susceptible to drought-induced deficiencies. They depend on the high streamflow that usually occurs in the spring. If low streamflow conditions develop in the spring, there is a risk that they will continue into the summer and fall, when runoff from even normal precipitation is relatively small. These smaller water supplies are likely to suffer shortages that could persist until the following spring, when conditions would again be favorable for surplus streamflow. Low streamflows in the spring are uncommon, but when they do occur they indicate that a serious drought condition exists.

Urban water shortages during drought are more likely in southern Illinois than elsewhere because droughts are typically more severe there and most public water supplies are surface impoundments. Most water supplies in central and

Dry weather in the spring leaves croplands susceptible to wind erosion.

northern Illinois come from deep groundwater, which is less affected by drought.

Groundwater Conditions During Drought

As with surface water, groundwater is affected by precipitation, but the effects are not as immediate and are prolonged to a greater extent. Groundwater levels are affected not only by precipitation, but also by evapotranspiration, runoff to streams, and pumpage from wells. In general, recharge to groundwater occurs whenever precipitation exceeds evapotranspiration and soil moisture demands.

Recharge to shallow aquifers near the surface can occur at relatively high rates, especially when the aquifers are composed of thick deposits of sand and gravel, which can rapidly store large amounts of water. Shallow aquifers, therefore, respond relatively quickly to precipitation events. When recharge ends, water levels in these aquifers begin to decline as groundwater moves toward discharge areas or is depleted by plants or pumpage. Prolonged dry periods significantly affect water levels in shallow aquifers.

By contrast, aquifers are often buried below materials that do not allow percolating water to pass through them rapidly. Large portions of Illinois are covered by such material, called drift, which was deposited by glaciers to thicknesses which often exceed 50 feet. During wet periods, the rate of recharge to the shallow aquifers may far exceed the rate at which water can move downward through drift material to the deeper aquifers. This excess is either stored in the shallow zones or runs off to streams. The shallow aquifers, in essence, act as reservoirs from which the groundwater can percolate slowly downward to replenish the deeper aquifers. Thus, recharge to deep aquifers is buffered from short-term precipitation events and deficits, and there is a lag time before these aquifers begin to show the effects of extended drought.

Drought Impacts

Drought affects everyone in the area involved, usually in a harmful way. The severity of a drought is usually defined by its impacts on the water needed by man and the environment. How fast conditions reach serious levels depends on the severity of the weather and on the area's soils, physiography, natural vegetation, human settlement, and land uses.

Water Survey studies of droughts lasting 12 months allowed us to assess how different levels of precipitation deficiencies in Illinois led to different levels of impacts. Figure 4 shows that in areas where the 12-month precipitation deficiency is 75% of normal (this would be 23 inches in northern Illinois and 30 inches in wetter southern Illinois), we find problems at the farm level including dry ponds and decreased crop yields. Where the 12-month precipitation is 50% of normal, all parts of the water supply system are experiencing shortages, and there are serious problems in all water-related sectors.

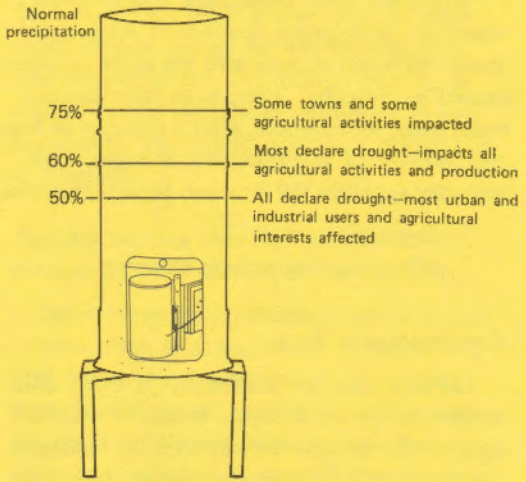


FIGURE 4. These are the impacts associated with different levels of severity of 12-month droughts in Illinois. Drought severity is expressed as percent of normal precipitation.

A drought's harmful effects are often accompanied by certain benefits.

It should be noted that certain benefits do accrue as a result of drought. Those who can haul water and drill wells often reap financial gain. Droughts also often cause certain stricken communities to later make needed improvements in their water supplies. These can include dredging silt out of a reservoir, increasing the spillway level, repairing leaks in the urban supply systems, or developing a major new supply, such as a larger lake or new wells. Such efforts cost money, but provide immediate employment opportunities and financial benefits to contractors. More importantly, the improvements make the community more resistant to the effects of future droughts.

Remedial Actions

There are both immediate and long-term responses to drought. Immediate actions are those employed to cope with the acute problems caused by drought. Long-term reactions are those used, for example, after a drought to lessen the impacts of a subsequent drought. The remedial activities fall into two broad categories:

* Conserving water
* Obtaining new sources of water

Conservation of Water

Conservation, unfortunately, is often only employed during drought. It can be attained by a variety of voluntary actions, by legislated incentives and by pricing of water. In households, flow restrictors can be installed on faucets, toilet tank capacities reduced, and if necessary, certain waste water caught and reused. In cities, water use can be restricted at car washes and for lawn watering, and water use in schools and other institutions can be reduced. Leaks in urban supply systems can be located and repaired.

Conservation can be voluntary, but often needs encouragement from local government or the water supplier. Urban and county government agencies can set fines for wasting water and set limits on usage. Water companies can also set higher rates that lead to reduced usage. A sustained conservation effort in non-drought periods employing the above actions, however, requires public education about the value of water, an understanding of the relationship between water quality and quantity, and an awareness by municipalities and private water companies of more correct water pricing.

Seeking More Water

Most cities in Illinois critically affected by drought can obtain larger supplies of water by effectively enlarging their reservoirs (by raising the spillway level or by dredging the silt from the reservoirs), by drilling new wells, and by constructing pipelines to larger water supplies. Most of these projects usually take months to years to accomplish, however, and therefore require advance planning and sources of added funding.

Rural dwellers, especially farmers, have sought more water by other means. They too drill more or deeper wells, and pay to have water hauled. They have also utilized cloud seeding projects to increase summer rainfall, have switched to irrigation, and in some cases have used monomolecular chemical films (hexadecanol) that can be spread over farm ponds to reduce evaporation.

A sustained conservation effort in non-drought periods requires public education about the value of water.

State and local drought contingency planning is necessary.

Some Recommendations for Dealing with Drought

Recent Water Survey studies have addressed the problems and impacts resulting from droughts in Illinois, as well as some of the many solutions to these problems. These studies serve as a basis for planning for the occurrence of future droughts, and as a basis for making future institutional and environmental adjustments. Our evaluation of recent droughts in this context led to four general recommendations for dealing with future droughts.

Develop local and state programs for addressing droughts in Illinois.

Better informed and organized state and local programs are necessary in drought contingency planning and reactions. Illinois now possesses the ability to predict, with some degree of confidence, future precipitation deficiencies including the starting and ending of droughts. For this information to be valuable, however, it must be readily available to those communities likely to be affected by drought, as well as to the government agencies that will be involved in assisting drought-stricken areas. They also must be aware of how to properly use the information. There is a need for better public education on water conservation, and the value of water, and for better, more reliable water sources and facilities. More accurate long-term monitoring of water usage is needed to help establish the use trends that are an essential part of planning.

Renovate older water supply systems.

The study of the 1980–1981 drought in Illinois highlighted this need for many communities. Sediment buildup significantly cuts down the water capacity of a lake. Dredging the silt, constructing higher spillway levels, and/or constructing new lakes are common solutions to this problem. Communities with older water distribution systems should improve treatment facilities, repair leaks in the system, and if necessary replace pipes. The users of the system should be made aware of the desirability of paying for such renovations.

Conserve, re-use, and re-price water.

Again, education is the key. Water users must be made aware of the real value of water, and must understand the relationships between water quality and water quantity. We need to realize that the price of water must include money for the maintenance and upkeep of the distribution system, as well as for the possible development of new supplies in response to changes in population or lifestyles.

Develop and use new technologies for increased supplies and better management.

More research and development is needed in areas such as precipitation enhancement and evaporation suppression. Innovative management geared toward stretching existing water supplies or developing new water supplies should be encouraged. Monthly and seasonal precipitation predictions show a great deal of promise as a management tool, and the development of more accurate predictions is being pursued.

This is the ninth in a series of pamphlets describing in popular language our research findings about water resources and weather in Illinois and current issues concerning them.

June 1984

DROUGHT

This brochure was prepared by *Steven D. Hilberg*, a meteorologist and Extension Services Coordinator at the Water Survey, and *Stanley A. Changnon, Jr.*, a climatologist and Chief of the Water Survey.

More information on droughts in Illinois can be found in the following Water Survey publications.

Drought Climatology of Illinois, Bulletin 50, by Floyd A. Huff and Stanley A. Changnon, Jr., 1963.

The 1980–1981 Drought in Illinois: Causes, Dimensions, and Impacts, Report of Investigation 102, by Stanley A. Changnon, Jr., Gary L. Achtemeier, Steven D. Hilberg, H. Vernon Knapp, Robert D. Olson, Wyndham J. Roberts, and Peter G. Vinzani, 1982.

The Illinois State Water Survey is the central data repository and research coordinator for Illinois in matters related to water resources and weather. Its research and service programs encompass assessment and evaluation of ground, surface, and atmospheric water resources as to quantity, quality, and use. The Water Survey was founded in 1895 and is now a division of the Department of Energy and Natural Resources.

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